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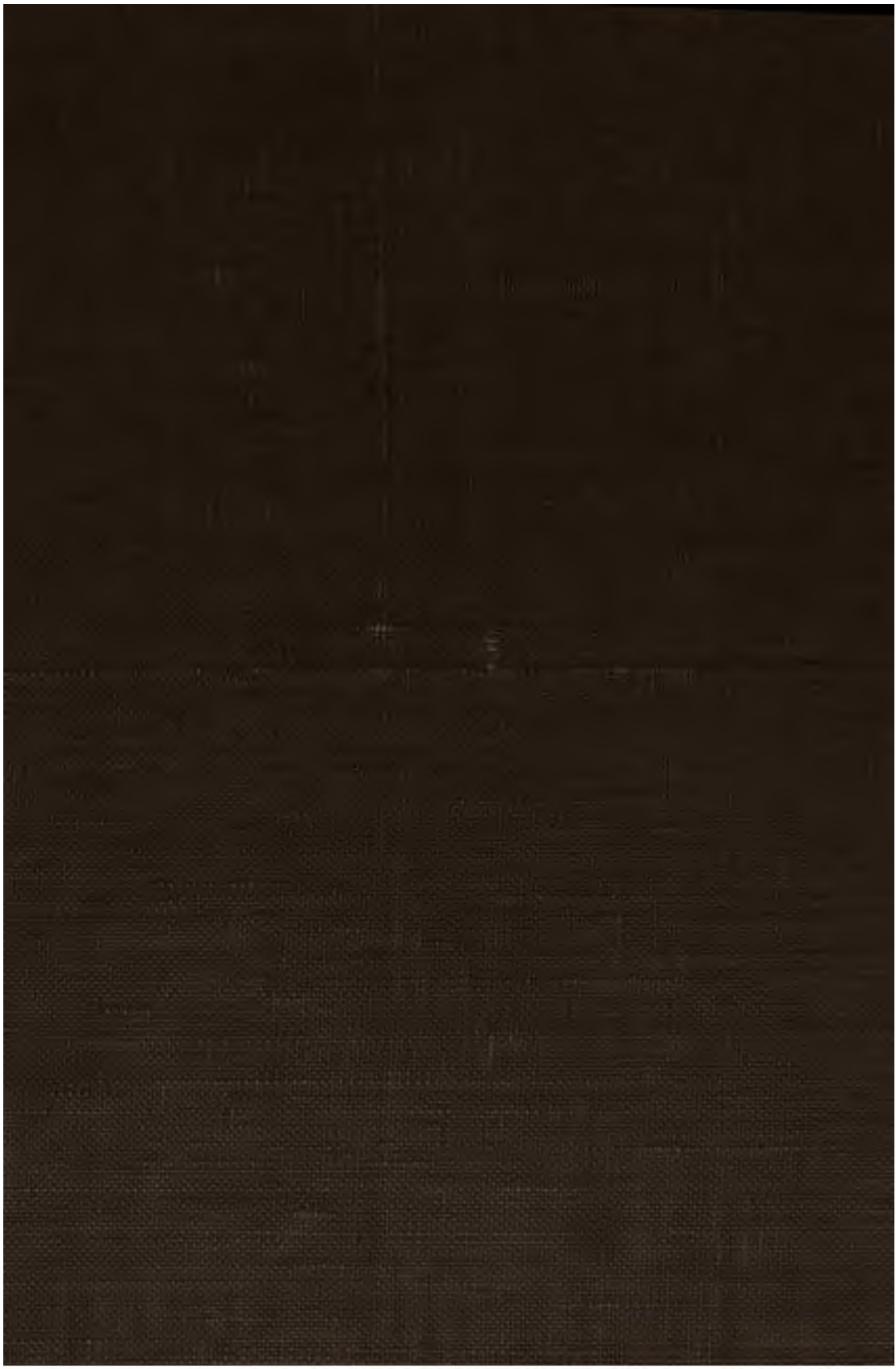

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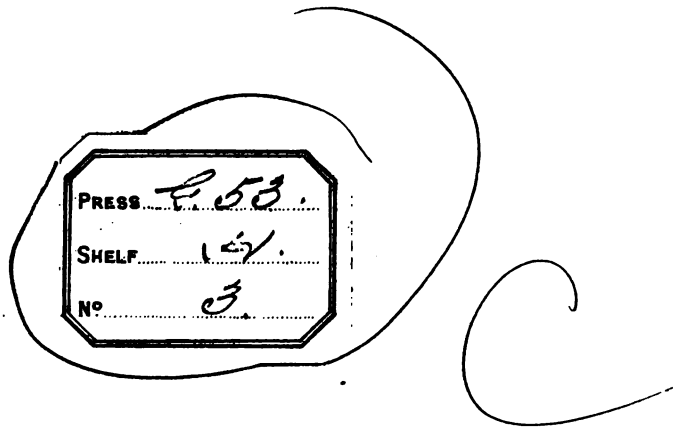

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PRACTICAL INFORMATION

ON THE

DEVIATION OF THE COMPASS;

FOR THE USE OF

MASTERS AND MATES OF IRON SHIPS.

BY

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PRACTICAL INFORMATION ON THE DEVIATION OF THE COMPASS; FOR THE USE OF MASTERS AND MATES OF IRON SHIPS.

Deviation, Variation, and Local Attraction.

1. "Deviation of the compass" is the term used exclusively to indicate the error of the compass from the attraction of the iron of the ship, whether employed in her construction, in her equipment, or in her cargo.

2. "Variation of the compass," on the other hand, should be applied exclusively to that error of the compass which arises from the magnetic poles of the earth not being identical with the poles around which it performs its diurnal motion.

3. "Local attraction" should only signify magnetic attraction, resulting either from volcanic or other natural magnetic bodies, or from iron cranes, water pipes, or pillars, which generally surround our docks; also the magnetic attraction of one iron ship on the compass of another ship should be termed local attraction. St. Helena affords an example of natural local attraction.

The Theory of Deviation.

4. Deviation of the compass differs both from variation and local attraction in depending both for its amount and direction, on the position of the ship's head by compass. Thus, if the force of the ship's magnetism were a constant quantity, the deviation will be greatest when the direction of the force that produces it is at right angles to the compass needle, and would cease to exist when the disturbing force is situated in the same line with the compass needle, attracting it either in the same or contrary direction to that of the earth.

5. But the force of the ship's magnetism is not a constant quantity, but varies as the ship's head is brought to different points of the compass. To understand this, it is necessary to consider the elementary laws of magnetism.

6. Magnets are of two classes, permanent magnets (13) and inductive* magnets, the former being generally composed of

* The law of induction is, that either pole of any permanent magnet induces in soft or cast iron a pole of a contrary name; that is, the north pole of a magnet induces a south pole in that end of the bar nearest to it, or the south pole induces a north pole. Also, north poles attract south poles, and south poles north poles, so that either pole of a permanent magnet attracts any piece of soft or cast iron by first inducing a pole of a different name, and then the general law of magnetism is obeyed by poles of different names attracting each other, except when the effect of the earth's inductive magnetism upon the piece of soft iron determines its polarity, then if a pole

hardened steel that has been magnetized, or the natural magnet loadstone. Inductive magnets are generally composed of soft iron or cast iron. The latter are only magnets whilst under the influence, termed induction, of a permanent magnet, and the poles of such inductive magnet are determined by their relative position with regard to such permanent magnet. On this account inductive magnetism is sometimes called the magnetism of position.

7. The earth is to be regarded as a permanent magnet producing inductive magnetism, in common with other permanent magnets; consequently all soft or cast iron bars or rods, or other elongated forms of soft malleable or cast iron, unless the position of their length be at right angles to the direction of the earth's magnetic force, become inductive magnets, varying in intensity, in proportion as they approach parallelism with the line of force. The line of force of the earth's magnetism is in the plane of the magnetic meridian, that is, to the point of the horizon to which the needle of the compass points, but depressed from the horizontal plane, according to the magnetic dip of the station on the earth's surface—at Liverpool about 70°, at London about 67° 30′.

8. In every other direction in which such elongated forms of iron are placed, the inductive magnetism will be equal to its force when placed parallel to the earth's line of force (7) multiplied by the cosine of the angle of inclination to that line of force. If at Liverpool an iron rod when placed in the magnetic meridian, but dipping 70° below the horizontal plane, possesses a magnetic force equal to the modulus,* which at right angles to the

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of the same name be induced, on an artificial permanent magnet being presented, they would repel each other.

A very simple experiment will illustrate the difference between inductive and permanent magnetism. Having a compass and a permanent magnet, mark the north pole of the latter, and also mark in a similar manner one end of a soft iron rod or cast iron cylinder. First place the permanent magnet at right angles and horizontally on the east side of the compass with the marked end towards it, and the south end of the compass needle will be attracted, causing the needle to deviate to the left; reverse the magnet and the compass will be drawn in the contrary direction. Then take the iron rod or bar and place it in the same position as the magnet, but no effect will be produced on the compass; but if we hold the bar vertically with the marked end downwards on a level with the compass card the needle will be drawn to the left. Still keep the marked end on a level with the compass with the other end of the bar downward, the needle will then be drawn to the right. Reverse the ends and the same effect will be produced. Thus, with a permanent magnet the result produced will depend on the pole presented to the compass; but each end of the iron bar produces the same effect if the position of the bar be the same, and contrary, when held in a different position.

* The term modulus signifies the magnetic disturbing force of the ship as compared with the earth's horizontal force, the latter being regarded as 1 or radius. The modulus, being generally less than the earth's force, is expressed by a decimal fraction, the same as the natural sine of the deviation produced when such modulus is at right angles to the needle, or generally by the sine of the deviation multiplied by the cosecant of the inclination of the ship's horizontal force to the direction of the needle; thus the natural sine of 10° is ·1736, and is equal to the modulus which at right angles produces 10° of deviation. But if the same modulus be inclined 22° 30′ to the needle the deviation will be modulus × sin 22° 30′ = ·1736 × ·3826 = ·0664 = sin 3° 49′, consequently the modulus multiplied by the sine of any other amount of inclination must be equal to the sine of deviation. The modulus of sub-permanent

needle would cause a deviation of 10°, that is, a disturbing force equal to ·1736, the earth's horizontal force being regarded as 1 or radius; the same rod placed in the magnetic meridian, but horizontally, would, at Liverpool, by induction have a magnetic force equal to ·1736 × ·342* = ·0594, or the above-named modulus multiplied by the cosine of 70°, the dip at Liverpool, the dip being the angle in which the line of force (7) inclines towards the horizontal plane. But if the same rod were placed vertically, or forming an angle of 90°, with the horizontal plane, it would then make an angle of 20° with the *line of force*, and its induced magnetic force would be ·1736 × cos. 20°, or ·1736 × ·9397* = ·1631. Thus in the latitude of Liverpool a rod of iron would possess nearly three times the inductive magnetic force if held vertically, that it would if placed horizontally on the magnetic meridian.

9. But there are much more important distinctions between the effects of inductive magnetism in vertical and horizontal iron on ship board. First, horizontal iron changes its magnetic force by induction (6), according to the angle it forms with the magnetic meridian, but vertical iron whilst in the same latitude retains the same amount of magnetic force with the ship's head

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magnetism is the same whatever be the direction of the ship's head, while the deviation arising from sub-permanent magnetism changes as the angle of its line of force with that of the direction of the needle changes. But the deviation produced by inductive magnetism on horizontal bars varies with the ship's head, from both causes. The modulus changes its value and the deviation is equally affected by the angle which the line of force forms with the needle, greatest at right angles, but 0 when in the same line. In the case of induced magnetism, therefore, when the modulus is greatest no deviation is produced because the line of force of the ship's magnetism and the direction of the needle coincide. On the other hand, when the bar is in that relative position with the needle in which with any given modulus the greatest deviation would be produced, there is no deviation, because there is no modulus when the bar is at right angles to the line of force. In the angle 45, to the compass needle, the greatest deviation from induction in horizontal iron is produced, and in this position the iron above alluded to (8) would only produce a deviation of + 1° 42′, which would be the nominal value of D (21).

* These factors are the natural cosines of 70° and 20° taken to three or four figures from Table xxvi. of Norie's Epitome.

Strictly speaking, it is the modulus and not the degrees and minutes of deviation that should be multiplied by these factors or sines. But to multiply the deviation itself being the more simple process it is generally employed. It is adopted in Sections 53 to 64, also in Mr. Archibald Smith's first method of finding coefficients, and constructing by them a table of errors (see foot note to 26). The Astronomer Royal, in a paper received by the Royal Society in November 1855, and printed in the Philosophical Transactions, gives a table of Polar Magnet Deviations with the modulus, and Mr. Archibald Smith has lately, in the Admiralty Manual (foot note to 26), also given a table for the practice of the exact instead of the approximate formulæ. The amount of error from using the more simple method is of no importance when a moderate amount of deviations is to be multiplied by a sine. But when large amounts are either to be thus multiplied, or when a great deviation is the result of the summation of disturbances arising from various causes, the error will be considerable. Thus, 10° × sin 45° = 7° 4′ and the modulus thus multiplied gives a deviation of 7° 3′, a difference of only one minute, but if we multiply the greatest deviation given in the Astronomer Royal's tables, viz., 53° 8′ by the sine of 45°, the product would by multiplying by modulus give a maximum deviation of 34° 27′, but if we multiply 53° 8′, that is, 3188 minutes, by the same sine it gives 2255 minutes, that is 37° 35′, an error of three degrees, because the sines increase less than their respective arcs increase.

in every direction; and, second, horizontal iron produces the same deviation in all latitudes, and in both hemispheres. For although the intensity of the inductive magnetism varies with the intensity of the earth's magnetism, the ratio between the two forces is always the same; and since the one is the directing force of the needle, and the other the disturbing force, it follows as a necessary consequence, that the deviation arising from the inductive magnetism of horizontal iron is the same for all latitudes. The case is different with vertical iron; for in the northern hemisphere the upper end of such iron attracts the north end of the compass needle, whereas in the southern hemisphere the upper end of vertical iron attracts the south end of the needle (foot note to 6).

10. It then becomes important that the navigator of an iron ship should be enabled to determine what amount of deviation arises from each of these disturbing forces.

11. The term "permanent" magnetism (13) must be understood in a restricted sense, both as applied to the earth's magnetism and to artificial magnets. It has been found that not only do the magnetic poles of the earth vary in long periods, but also, to a small extent, there is a diurnal change. Artificial magnets or needles are also subject to changes in their intensity, although if carefully made they may be rendered as permanent as any other artificial production. The dipping needle of the Liverpool Compass Committee, although made in 1855, has not in eight years changed its magnetic intensity to any perceptible amount. But not so with what has been called the permanent magnetism (13) of iron ships.

12. The permanency of a magnet depends principally on the condition of the steel of which it is constructed. The materials of an iron ship possess little of those qualities which are required in the production of a permanent magnet, consequently absolute permanency of any portion of the magnetism of an iron ship could not have been anticipated. The materials of which an iron ship is constructed would acquire an amount of magnetism for a limited period if held in the line of force (7), and subjected to percussion by the stroke of a hammer or otherwise; but the poles of such a magnet would be reversed if the position of the ends were placed in the contrary direction, and the iron subjected to a similar amount of percussion. But the magnetism of this iron is more retentive when constructed into a ship than when experimented on, in the form of angle iron or plates, and although most ships retain a considerable amount of the magnetism which they acquired during the period of their being built, as long as the iron remains united in the form of a ship, still the intensity undergoes a considerable diminution in a very short period if a ship be placed in a graving dock, or be equipped for sea, with her head in the contrary direction to that in which she was built. Still, generally, under no circumstances does a ship part with the whole of the magnetism acquired whilst being built, and in no case does she retain the whole of the mag-

netic force thus acquired; it is, therefore, desirable with regard to a new ship, that it should be fitted for sea, or otherwise subjected to external force, with the direction of her head reversed. If this precaution be not adopted the deviation of the compass may be subjected to a considerable amount of change whilst going down channel, and the safety of the ship thus jeopardized.

13. From what has been said, it will be apparent that the term "permanent" is not accurate when applied to the magnetism of an iron ship. Dr. Scoresby perceived this, and proposed to designate as "retentive magnetism" the portion of the magnetism acquired on the building slip, which was retained after launching; and which he considered was retained only for a period, and under certain circumstances might be lost altogether, or even reversed. But experience has shown that this is a misapprehension, for although a ship does not retain the whole of the magnetism acquired on the building slip, yet it is certain that in all our iron ships some portion of the magnetism so acquired remains permanent. And we agree with the Astronomer Royal, Professor Airy, in calling this residual magnetism "sub-permanent magnetism." A striking illustration of this is afforded by the "Great Britain." Though this extraordinary ship has been stranded, strained, altered, and has been in active service in both hemispheres, yet her magnetism still indicates the position of her head when she was built.

14. We would, however, retain the term "retentive magnetism," to distinguish the magnetism which a ship may subsequently acquire from lying for any considerable period in one direction, either on a voyage or in dock. This magnetism never assumes a sub-permanent character, but is lost or reversed by altering the circumstances which produced it. This retentive magnetism increases the force of the sub-permanent when produced with the ship's head in the same direction as that in which she was built, but decreases it if in the opposite direction, and modifies it if in any other direction. The case of the "Tiber" affords a very striking illustration of the difference between sub-permanent and retentive magnetism. With her head in the opposite direction to that in which she was built, she came into collision with another vessel. The retentive magnetism thus produced was for a time greater than the sub-permanent magnetism, but when she had arrived at Liverpool the sub-permanent magnetism that had existed previously to the collision was very nearly restored.*

* When we say that an iron ship possesses magnetism of three different kinds, we do not imply that any portion of the ship's iron possesses exclusively magnetism of either character. Each portion of the ship's iron or the ship as a mass possesses a certain amount of magnetism, a part of which is permanent, a part retentive, and the remainder is inductive, but it is more convenient in investigating the effects produced on the ship's compasses, and also more effective in compensating deviation to adopt the hypothesis that these instruments are acted on by three distinct magnetic influences, in the same way as we regard the polar magnetism as two forces, one to or from the bows, and the other to or from the starboard side (17). The late Sir James C. Ross makes no distinction between retentive and induced magnetism, but

15. In observing or calculating the deviation we do not regard the relative position of the earth's magnetic meridian and that of the line of the ship's horizontal force,* since with any given amount of disturbing force the deviation will depend on the relative positions of the line of the disturbing force with that of the disturbed needle, the deviation of which we are determining, the greatest deviation occurring when these are at right angles to each other. If then the maximum deviation of any compass were four points easterly, with the ship's head north by such compass, and the same amount four points westerly, with the ship's head south by compass, the correct magnetic bearings of her head, at the same times, would be N.E. and S.E. So that if we bring her head round 24 points, that is, from N.E. to S.E., correct magnetic, by the west, by compass she would appear to have moved only 16 points. On the other hand if the ship's head were brought round by the east, thus moving only eight points correct magnetic, by compass she would still appear to have changed the position of her head 16 points. This is one of the evils connected with uncompensated compasses when the deviations are large (foot note 33).

16. The poles of the ship's sub-permanent magnetism are parallel to the magnetic meridian during the time she was being built, therefore little if any deviation is produced by the sub-permanent magnetism when her head is in the same direction. The only effect on the compass then produced by sub-permanent magnetism, is to reduce the directive force of the needle. On the other hand, if the ship's head be brought into the contrary direction to that in which she was built, the only effect produced by the sub-permanent magnetism would be to increase the directive force of the needle. The first result is rendered evident by the sluggish movement of the compass card; the latter by its greater activity. When the deviation has been very great the sluggishness of the motion of the compass card

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shows that the latter requires time and percussion to produce its full development. The facts here described are the same as those observed by Sir James Ross, but differently expressed for the purpose of rendering the calculation of results more simple. The modification of sub-permanent magnetism by retentive magnetism is much more obvious in cases of ships engaged in the Australian trade, when compared with that experienced on board of ships making voyages to and from India or China. In the former cases the ship's head is generally kept easterly during both the outward and the homeward voyage, and consequently the attraction towards the starboard side (+ C) is increased by retentive magnetism (14), or that towards the port side (− C) is reduced. But not so with ships sailing outward and homeward by the Cape. The heads of such ships being kept easterly outward and westerly homeward. In these cases the change of deviation arising from induction on the outward voyage is more or less compensated by the inductive influence of the earth acting in the contrary direction during the voyage home, and on returning to port the change is found to be very small when compared with that observed on board Australian ships. In the case of the "Royal Charter" this change amounted to no less than two points.

* The Astronomer Royal, in his paper read before the Royal Society, November 22, 1855, gave a formula to refer the azimuth of the polar magnet to the correct magnetic meridian, and Mr. Archibald Smith in the Admiralty Manual (foot note to 26) has given tables to facilitate this calculation, but it is presumed that it will be more practicable for the mariner to found all his calculations from deviations determined from observations made with the ship's head on certain points by compass.

has rendered the compass useless when the ship's head has been in certain directions, and this is another evil connected with uncompensated compasses. On the other hand, the deviation arising from sub-permanent magnetism is a maximum when the line on the ship's deck, which corresponded with the magnetic meridian at the time the ship was being built, is at right angles to the compass needle, either to the right or the left; consequently the deviation produced by sub-permanent magnetism is denominated semicircular or polar deviation, being a maximum in the two opposite directions (46).

17. Although the poles of the ship's sub-permanent magnetism are always in or near that line of the ship that corresponded with the magnetic meridian at the time she was being built, it has been found desirable for the purpose of simplicity of investigation, when the line of force passes obliquely to the fore and aft line, to resolve the sub-permanent magnetism in the direction of the keel and at right angles to it. Adopting the notation of Mr. Archibald Smith, we have + B towards the ship's head — B towards the ship's stern, + C to the starboard side, at right angles to the fore and aft line, and — C towards the port side. $\pm$ B and $\pm$ C are called coefficients; the inductive magnetism of vertical iron also produces $\pm$ B and $\pm$ C (foot-note to 61).

18. The coefficients, referring to sub-permanent magnetism, will depend on the direction of the ship's head, whilst she was being built. If her head was south at that time the coefficient acquired would be + B, that is a sub-permanent magnetic attraction towards the bow; if her head were north we should have an attraction towards the stern, represented by — B; if to the east the principal coefficient would be + C, representing attraction towards the starboard side; but if she was built with her head west, the principal sub-permanent attraction would be to the port side, represented by — C. If the ship's head were in any other direction than the cardinal points, the coefficients would be either + B or — B, together with + C or — C; and + B or — B would be the greater when the southing or northing of the direction of her slip exceeded its easting or westing, thus, if her head were in a N.N.E. direction at the time of her being built, — B would be greater than + C, because the direction of the slip was nearer north than east. In speaking of the needle being attracted to any part of the ship it should always be understood to refer to the north end of the needle.

19. Coefficient + B produces the greatest easterly deviation with the ship's head east by compass, and the greatest westerly deviation with her head west; on the contrary, — B produces the greatest easterly deviation with the ship's head west and westerly with the ship's head east. The magnetic disturbance represented by + C produces the greatest easterly deviation when ship's head is north and westerly when south; if it be — C the reverse is the result.

20. Deviation caused by the induced magnetism of horizontal iron (9) is also represented by two coefficients D and E, but the

latter is generally small. + D gives easterly deviation with the ship's head between north and east and between south and west, but westerly deviation when her head is between south and east and between north and west. The effects of − D produces westerly in the two quadrants in which + D causes easterly; and easterly where + D produces westerly. The deviation caused either by + D or − D is greatest when the ship's head bears N.E., S.E., N.W., and S.W., by compass, and is therefore called quadrantal deviation.*

21. + D may be regarded as the inductive magnetism of iron beams extending athwartship at right angles to the fore and aft midship line of the ship. But if the beam be divided† to introduce a skylight, or otherwise, and a compass placed between the two parts of the divided beam, − D will be the result. Also, iron extending fore and aft produces − D, except when divided and the compass introduced between the two parts thus divided, then it will give + D. Cannon produce − D. In practice we seldom find − D, it being generally more than compensated by a larger + D.

22. Coefficient E represents the effects by the inductive magnetism of horizontal iron placed in the angle 45° to the fore and aft midship line of the ship. If the direction of this iron be from the starboard quarter towards the port bow, it produces + E. But in a line from port quarter towards starboard bow, − E. The same remark holds good with regard to + or − E as has been made in reference to + or − D. If iron is situated so as to produce a minus or plus coefficient when continuous, by taking away the centre part and placing the compass between the divided ends, the sign will be changed, + E becoming − E, or − E is changed to + E. Both + E and − E produce their greatest effect with the ship's head on the cardinal points by compass + E give easterly when the ship's head is either N. or S. and westerly when E. or W. On the contrary, − E gives westerly on the former two points and easterly on the two last-named points; both + E and − E become 0 with the ship's head S.E., N.E., N.W., or S.W. by compass; it is therefore, together with D, called quadrantal. The same iron frequently produces D and E.

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* The following is a quotation from the Liverpool Compass Committee's third report :—"1. Quadrantal deviation may be large in amount in a small ship, and the reverse; 2. Generally it is larger in amount in the middle of a large ship than in positions nearer to the ends; 3. It decreases rapidly as the compass is raised above the deck, and at a certain height above it may be changed from plus to minus. 4. In the usual positions for a compass the quadrantal deviation is almost invariably plus, but it may be minus in a compass placed over a hatchway or skylight, or on the bridge between the paddles of a paddle-wheel steamer, or, as before stated, at some height above the deck, as on a mast."

† Divided iron produces opposite effects to those caused by iron extending across from the port to the starboard side; because, if divided, it must be regarded as two separate inductive magnets, one on each side of the compass; but, if continuous as one magnet with the compass between the two poles. In the case of divided iron the attracting end nearest the compass is on the northern side of the compass, and the nearest end of the opposite magnet is a repelling pole on the southern side, but in *continuous* iron the attracting end of the inductive magnet must be on the southern *side of the compass, and the* repelling pole on the northern side.

23. The remaining coefficient, A, is a constant quantity, not changing with the direction of the ship's head, +A being always, easterly, −A always westerly. Although A may be produced by a certain unsymmetrical arrangement of iron, and sometimes together with E, yet it more frequently appears to exist from errors connected with observation, or from an index-error of the compass, arising from the poles of the needles not being parallel to the north and south line of the card. From this last source in one case an error of $13\frac{1}{2}°$ easterly arose; whenever, therefore, this coefficient appears large, the compass should be very carefully examined. By changing the card, an error arising from this source will be detected. An error in observing the correct magnetic bearing of the object on shore when the ship is swung will give an apparent coefficient A. Also, when the deviation is determined by azimuths, an error in the estimate of variation (2) will give the same result.

24. To guard against the evils arising from deviation of the compass, two systems have been adopted. The first is to determine the deviation of the compass on each point, and entering the same in a table of deviations, to be used either on courses steered or when shaping a course. The second method is to compensate with permanent magnets and soft or cast iron. But it seldom occurs that a perfect compensation can be effected, and if the compensation were perfect it would not probably remain so, but would with time and change of the latitude of the ship and other causes undergo a considerable change. On this account the advocates of compensation usually reduce the deviation to a small amount, and give a table of remaining deviation obtained in the same manner as a table of deviation for uncompensated compasses.

Means for determining the Amount of Deviation.

25. After the ship has all her iron stores on board, and in place, whether for the purpose of compensating her compasses or otherwise, their deviations should be determined by one of three different methods.

26. If practicable, this should be done by observing bearings by compass of some distant object, with the ship's head successively on each of the points of the compass, or on as many points as is convenient * (119.) The object selected for this purpose should be at such a distance from the ship that the diameter of the circle in which the compass revolves shall make no sensible difference in the real bearing of the object. The diameter of the circle should not exceed a hundredth part of the distance of the object. If the ship be in a tide-way, the distant object should not be less distant than 7 or 8 miles. But if the ship is swung in a dock, a less distance will suffice, espe-

* All who undertake to swing a ship for a deviation table should consult the "Admiralty Manual for ascertaining and applying the Deviations of the Compass," edited by F. J. Evans, R.N., F.R.S., and Archibald Smith, M.A., F.R.S.; parts I. and II.

cially when the compass or dumb-card* with which the correct magnetic bearing of the ship's head is determined is about midway between the bows and stern of the ship.

27. When there is no suitable object sufficiently distant for the purpose of determining the correct magnetic bearing at the ship, the process by reciprocal bearings is generally adopted. One observer is on shore with a second compass in some open space visible from the ship; and when the ship's head is at rest on a point where the deviation is to be determined, at the same instant (known by a pre-arranged signal) the observer on shore takes the bearing of the standard compass, and the observer on board takes the bearing of the compass on shore by the standard compass. The bearings by the compass on shore should be reversed previously to being compared with the bearings by the compass on board, the difference will then be the deviation. When by the compass on shore the bearings (thus reversed) appear to the right of those given by the compass on board, the deviation is easterly, if to the left westerly. Example:—The standard compass bears by the compass on shore S. 41° E., when reversed N. 41° W.; by the standard compass on board, the compass on shore appears to bear N. 22° W.; the deviation on this point is 19° W. There is, however, no method of determining the deviation of the compass that requires so great caution, and which is so calculated to lead to error on account of the effects of local attraction (3) on the shore compass. Whilst that system was adopted at Liverpool, errors of considerable amount were committed. But in cases in which no other method can be resorted to, great care must be taken that the shore compass should be as free from local attraction as possible, and when practicable a time azimuth (80 to 118) should be observed to verify the bearings by shore compass; but implicit reliance cannot even then be placed in the results thus obtained, since the movement of any iron ship in the dock† or even the motion of the ship that is being

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* The dumb-card, or card without a needle, is a most convenient instrument, either for swinging a ship or for determining the error of the compass by the azimuth of any heavenly body, especially when the correct magnetic bearing is previously known. The lubber line of the instrument having been fixed towards the ship's head, and the sight-vanes having been screwed to the card at the known magnetic bearing of the object to be observed, then on turning the card with the sight-vanes to the object, the bearing of the ship's head true magnetic will be given opposite the lubber line. Otherwise at sea the sight-vanes may be fixed at the true bearings of the object, when the correction (79) of the compass will be shown. Since, however, there are several descriptions of dumb-cards manufactured, it is necessary to observe that all dumb cards should be on gimbals, or they give incorrect results. Commander Hay, R.N., has contrived a compound protractor, which, in addition to many other valuable aids it afford the mariner, may be made use of instead of a dumb-card, provided the vessel is steady. When it is required to adjust these instruments to the true or correct magnetic, time azimuths alone can be employed for that purpose (80). The correction of the compass is the term that is used to indicate the degrees and minutes to be added to or subtracted from the compass bearing, to correct both for the variation and deviation together.

† In one case the writer was determining the error of the compass by taking azimuths at short intervals for the purpose of taking the mean, but was surprised to find that the last observation made the sun very perceptibly to the eastward of the first; this he found to have arisen from the attraction of a large iron ship which in

swung, may occasion perceptible but not very large amounts of error. In most cases the shore compass has during the process to be removed to two or three stations. In such cases the local attraction, if any, at each station, should be subsequently determined.

28. These difficulties are, however, greatly reduced in Liverpool by a system of magnetic bearings in the Clarence and Wellington half-tide docks, but even with this arrangement the presence of other iron ships in the same dock may interfere with the accuracy of observations thus made. In addition, therefore, to the marks on the inside of these docks, the outer walls have the bearings of the Vauxhall chimney painted on them in large figures visible from the river.*

29. There is no error more frequently made than that of naming easterly deviation westerly, or westerly easterly. This arises chiefly from the explanation of E. and W. deviation given in books on navigation. Being informed that the deviation is westerly if the north end of the needle is drawn to the west, and if drawn to the east easterly, if the bearing by compass on board is too much easterly, the mariner frequently imagines that the north end of the needle is drawn to the east, whereas the contrary is the fact. The needle is drawn to the west, and by that means the east point on the compass card is drawn towards the direction of the body whose bearing is observed, which makes it appear by compass eastward. If the *correct* magnetic bearing be to the right of the bearing, by the compass on board, the deviation is easterly, if to the left westerly.

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being warped out of dock had her bows, which had been previously north of the compass, brought towards the west. This ship's head, it was afterwards ascertained, was nearly north when built, giving her compass a large — B, and thus repelling the north end of the needle, which caused the east point on the card to approach the direction of the sun.

* In order to prevent northerly bearings being mistaken for southerly, all the bearings are given easterly from the magnetic north. Thus, south would be expressed 180°, S.E. 135°, and east 90°; when the number on the wall exceeds 90°, to change it to a southerly bearing it must be taken from 180°. In the Clarence and Wellington Dock, the bearings of two objects are given, in case that one is obscured by any intervening object, the other may be observed; on the west side of the Wellington Dock the bearings of a tall post distinguished by a ball at the top, and on the north side the bearings of the Huskisson chimney. The mark on the north side of the Clarence dock gives the bearings of the centre of the Victoria clock tower, and those in the east side show the bearings of the Vauxhall chimney.

Similar facilities are also given at Kronstat. Capt. J. Belavenetz, of the Russian Imperial Navy, has made the following arrangement in the commercial port of Kronstat to enable mariners to determine the deviations of their compasses, as resulting from the effects of the iron of the ship, or the cargo on board, whilst lying at anchor in the great roadstead of that port: viz.—

The true bearings of the foundry chimney from various parts of the western wall of the commercial port of Kronstat are indicated by a series of marks, ranging between the bearings of N. 89° E. and S. 79° E., painted on the western face of the wall.

The degrees are marked in figures legible from the roadstead of Kronstat, the even figures being on a black ground, and the odd figures on a red ground in the following order, indicating as here stated, under each figure,—

79	80	1	2	3	4	5	6	7
S. 79° E.	S. 80° E.	S. 81° E.	S. 82° E.	S. 83° E.	S. 84° E.	S. 85° E.	S. 86° E.	S. 87° E.

8	9	90	9
S. 88° E.	S. 89° E.	East.	N. 89° E.

Discussion of the Advantages and Disadvantages of Mechanical Compensation.

30. It has been a contested point among those who have directed their attention to the compass deviation whether it is the more desirable to adopt mechanical compensation on principles introduced by the Astronomer Royal, Professor Airy, or to obtain a table of error and allow the compass to remain uncompensated. Compensation has for many years been generally, if not universally, adopted in the mercantile marine, and the system of relying solely on a table of errors for compass correction in H.M. Navy.* We will consider the merits of the two systems previously to an explanation of the method adopted for compensation.

31. Compensation by magnets does away with one of the errors to which an uncompensated compass is liable. There are changes to which the magnetic condition of an iron ship is subject, which must affect alike compensated and uncompensated compasses, but in addition to these sources of error an uncompensated compass changes its deviation with any alteration that occurs in the amount of the earth's horizontal force, and this takes place when the ship changes her station on the earth's surface; for instance, if from sub-permanent magnetism in the Bay of Bengal an uncompensated compass had a deviation of nine degrees, in the Gulf of St. Lawrence it would have a deviation of thirty degrees from this source.†

32. A compass compensated by iron chain or cast-iron correctors is less affected by the heeling (68) of the ship than the same compass would be if uncompensated, and consequently is less disturbed by the rolling of the ship. The last-named advantage is greatly increased when the compass is compensated for the effects of heeling by a vertical magnet (foot-note to 69, and Appendix D).

33. In many cases a compass, which would have been useless if uncompensated, has been rendered a very useful compass by compensation.‡ (15.)

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* Up to a recent period, tables of deviation have been exclusively employed in the Royal Navy, but of late the great amount of deviation found to exist in certain positions on board the iron frigates, "Warrior," &c., has *obliged* the Admiralty Compass Department to have recourse to compensation. For many years compensation has been adopted in the mercantile marine.

† By reference to the chart of lines of equal horizontal force, in the Admiralty Manual (foot note to 26), it will be seen that in the Bay of Bengal the earth's horizontal force is 2·3, but in the Gulf of St. Lawrence only ·69. These will therefore be the ratios of the directive forces of the needle at the two stations. Now if the ship's sub-permanent magnetism be the disturbing force, and remains the same, the deviations will be in the inverse proportion to the directive force; thus in the Gulf of St. Lawrence the deviation would be as much greater than it was in the Bay of Bengal as 2·3 is greater than ·69. It is supposed in this statement that the whole or principal part of semicircular disturbance is caused by the ship's sub-permanent magnetism (16). This will be true when the compass is not placed very near a vertical iron stanchion or other vertical iron (38), or when a vertical rod has been introduced (41), as proposed by Mr. Rundell, to neutralize the effects of such vertical iron.

‡ An experimental compass placed above the aft side of the round house of the "City of Baltimore," with the ship's head N. 1° W., correct magnetic, appeared by

34. If a compass be approximately compensated one of the most embarrassing matters, with which the practical mariner has to contend, is cured (15). A table of compass deviation constructed with the ship's head by compass on each point is generally given to the master of an iron vessel. This is what we require in correcting a course steered in order by a traverse, or day's work, to determine our latitude and longitude by account; but not so, if we wish to shape our course. We then require a table appropriate to ship's head correct magnetic. This frequently differs a point from the deviation given in the table. We will instance an uncompensated standard compass, and an approximately compensated compass, both on board the "City of Baltimore." The maximum deviation from all causes of the former is 21° 45′ on an even beam, not beyond the ordinary amount of deviation to which uncompensated standard compasses on board iron ships are liable. With her head S.W. by S. by compass, the deviation is 18° 50′ E., but with the head S.W. by S. correct magnetic is only 10° 8′ E., three-quarters of a point less than when her head was in the same direction by compass. But with regard to the approximately compensated compass, the maximum error of which is 4° 40′, the greatest difference for any two bearings, one by compass and the other the same point correct magnetic, is only 0° 16′, and may therefore be disregarded, and the same table of correction employed both in correcting courses steered and in shaping a course to be steered, only in the former case easterly must be applied to the right, and westerly to the left, in the latter, the reverse.

35. The objections to compensation are, first, that a master of an iron ship, if the compasses are compensated, places implicit confidence in them, and is thus led into danger. There can be no doubt that at one period the infallibility of compensation was credited to a dangerous extent, but it may be stated with confidence that there are few instances, if any, of masters of iron ships now entertaining this idea, and therefore this argument against compensation cannot avail.

36. Secondly. It has been objected to compensation by magnets that another source of error is introduced; that the compensating magnets are liable to lose their force. But it remains yet to be shown that, in a single instance* on board an iron ship, that any magnet has lost more of its magnetic force than the ship, and if a compensating magnet should lose any of its magnetism less than the reduction of the ship's magnetism,

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compass to have her head N.W. by W., but should she yaw four degrees to the left, viz., to N. 5° W. correct magnetic, her compass would move round ten points, that is, from N.E. by E. to N.W. by W., full twenty-eight times as much as the real change of the position of the ship's head (see third report of Liverpool Compass Committee, p. 46). The steering compass of the "Aphrodita" was similarly and equally defective, but when compensated there are very few more reliable compasses to be met with on board of an iron ship.

* On board wooden ships instances have occurred of magnets having their poles reversed by a stroke of lightning, but no such result can probably occur on board an iron ship.

this would be an advantage instead of a disadvantage, by compensating to some extent the change of a deviation which would otherwise take place. In fact, Mr. Rundell, who has made more practical observations in these matters than perhaps any other person, in the Appendix to the Third Report of the Liverpool Compass Committee (foot-note to p. 127) recommends that the sub-permanent magnetism should be in part compensated by soft iron, which would in common with the iron of the ship gradually part with some of its magnetism, and be liable to acquire and part with retentive magnetism.

37. And, thirdly, an objection has been urged against compensation, and especially with regard to the steering compasses of ships belonging to the mercantile marine* that polar (41) magnetism arising from induction on vertical iron at the stern, such as the stern post, rudder head, &c., if compensated by permanent magnets, would cause very serious error, if the ship proceed from these regions to high south latitudes.† This is undoubtedly a matter that demands serious consideration, but only proves that compensation should be modified to meet this case, and not that compensation should be abandoned altogether (41).

38. The theory of magnetism being understood, the compensation becomes a simple matter. We have two descriptions of deviations to compensate, the polar (17) and the quadrantal (20). The former is the result both of the sub-permanent magnetism of the ship and the inductive magnetism of vertical iron. Whilst the ship is in the same magnetic latitude, the deviation arising

* On board Her Majesty's ships the disturbance of the steering compass by the magnetism induced in vertical iron at the stern is not experienced, on account of the steering wheel and compass being before the mizen mast.

† An extraordinary instance of this class occurred about nine years since. The first voyage that an iron ship had made was to Australia. She was built with her head nearly north, which position would give her a coefficient — B from sub-permanent magnetism, and at the station where the steering compass was placed, a large — B in northern latitudes from the inductive influence on the stern-post, rudder-head, and other vertical iron there situated. The whole of this was compensated by magnets, and so completely, that when swung she exhibited no noticeable amount of deviation. The captain pronounced the compensation to be so perfect as to render another compass unnecessary. When making southing on his voyage, the ship's head being contrary to the position in which she was built, the sub-permanent magnetism became reduced considerably in force, and as the magnetic dip decreased the intensity of induced magnetism of vertical iron decreased in proportion (9), and after the magnetic equator was crossed, the induced magnetism of vertical iron repelled instead of attracting the north end of the needle. Now, both compensating magnets and inductive magnetism acted together, instead of the former compensating the latter, and this repulsion of the north end of the needle increased until the compass became sluggish in the extreme. Thick weather then came on, when it was found impossible to bring the ship's head on her course by compass. When it cleared up, the ship was found to be close hauled with her head within three points of the opposite direction to her correct course. The captain then found that the lubber line was always nearly north by compass in whatever direction the ship's head was brought, so that neither putting the helm to starboard or port caused her to appear nearer to her course, correct magnetic, which should have been E.S.E. The captain then ordered the magnets to be taken away, and although a deviation remained, still, by allowing for deviation, she was steered by compass without difficulty. The errors committed were two, the one above referred to, and the more serious one of relying solely on the steering compass, which is, on board ships belonging to the mercantile marine (foot-note above), beyond comparison more liable to this class of error than any other compass on board the same ship.

from both these may be compensated by steel magnets, but the quadrantal deviation can only be compensated by soft or cast iron, because permanent magnets produce contrary deviations with the ship's head in opposite directions, but quadrantal deviation is of the same name at opposite points. If, therefore, with the ship's head N.E., quadrantal deviation be eight degrees easterly, it will also be easterly deviation with the ship's head S.W. But if the same amount of deviation were the result of polar magnetism if it were easterly in the first-named direction of the ship's head, it would be westerly in the second; if therefore we were to compensate by magnets the eight degrees of easterly deviation when the ship's head was S.W. we should have double the amount of deviation with her head N.E., in which direction the compensating magnet and the quadrantal deviation would each produce eight degrees of easterly deviation.

39. There are, then, three descriptions of deviation, each (7, 8, 9, and 13) obeying different laws, there ought, therefore, to be three different classes of compensation. Quadrantal plus (20) can only be compensated by quadrantal minus; polar deviation produced by sub-permanent magnetism should be compensated by permanent magnets (17); and the polar deviation (9) produced by induction in vertical iron should be compensated by an equal attraction induced in a vertical iron bar on the opposite side of the compass.

40. To distinguish quadrantal from polar deviation is easily accomplished (38), but to distinguish that part of polar magnetism arising from induction on vertical iron from that which is produced by sub-permanent magnetism is a more difficult task. Yet with regard to vessels that cross the equator this is of the highest importance (foot-note to 37).

Partial Compensation to be made in building or fitting the Ship.

41. This last-named department of compensation should be the first attended to with ships required for southern voyages, although it cannot be undertaken with the same amount of exactness as the remainder, yet there is no difficulty in reducing it considerably. With ships built with their heads east or west, little or no deviation represented by $-B$ can result from the ship's sub-permanent magnetism. Consequently, if whilst in the building slip, the needle is drawn considerably towards the stern, we may conclude that it arises chiefly from the inductive magnetism of the iron at the stern. But this is not the case on board of ships built with their head in any other direction.* In these

* On board the "Simla" the B of the standard compass was + 3° 11′, that of steering − 12° 57′, therefore B due to induced magnetism appears to be − 16° 8′. The "City of Baltimore" is a case in which all the compasses had − B. on account of her head being in the position calculated to produce a sub-permanent attraction towards the stern, but B of the standard compass was only − 18° 7′, but that of the compass placed on the aft side of the round house was − 55° 12′; we may therefore infer that that amount of deviation to be compensated by upright iron is

the amount of the vertical induced magnetism can only be approximately estimated when the ship's head is brought east or west by compass, and by then comparing the deviation of the steering compass with that of the standard compass. In all cases, however, a vertical iron bar should be placed on the fore and aft midship line in front of the station where the steering compass is about to be fixed.*

42. The process described above can only be regarded as an approximate compensation of —B arising from induction; first, because the standard compass may to some extent be under the influence of the inductive magnetism of vertical iron, and, secondly, the value of B arising from sub-permanent magnetism may be different at the stations at which the steering and standard compasses are placed. But it is satisfactory to find that in the fifteen ships in which the experiment has been carried out by Mr. Rundell (see page 34 of the third report of the Liverpool Compass Committee), in each case it has been attended with more or less success. In every case the evil intended to be compensated has been reduced. In no case has it been over-compensated. But these bars in ten ships were placed after the ship was launched, and were consequently short, so as not to interfere with the cabin fittings.

43. Although the compensation of this element of deviation should only be reduced considerably previously to proceeding to sea, yet after the ship has crossed and recrossed the magnetic equator, and experiments there made respecting the value of the changing part of, B on her return to port, it may be rendered nearly perfect. In the case of compensation of the other parts

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— 37° 5′. In the cases of the "Advance" and "Slieve Donard," built with their heads south of east, and the "Astræa," built with her head south of west, the sub-permanent magnetism must give + B, so that we have not only compensated the — B of the steering compass by the vertical iron, but it must be placed sufficiently near to give it a + B equal to that of the standard compass, and compensate the + B by a fore and aft magnet in the manner hereafter described. The deviation to be compensated by upright iron is in each case the difference between the value of B in the steering, and in the standard compass, the B of the latter being always algebraically subtracted from that of the former. Thus, — 12° 57′ less + 3° 11′ is — 16° 8′, and — 55° 12′ less — 18° 7′ is — 37° 5′, or if, as is possible, the steering compass had a small + B from sub-permanent magnetism, and the standard compass a much larger, say the former + 18° 7′, the latter + 55° 12′, then + 18° 7′ less + 55° 12′ would give — 37° 5′, the value of B to be compensated by vertical iron.

* This should be done during the time of building, and the lower end of the bar should be riveted to the framework of the vessel. If built with her keel east and west magnetic, the station for the compass can then be approximately determined by observing the distance from the bar at which the north end of the needle is not drawn towards the stern. The "Aphrodita," built with her head east, had a — B of nearly 30°, arising from induction on stern vertical iron, and this might have been approximately determined before she was launched; the bar was not however applied until the building of the ship was completed. Although this is not the most satisfactory mode of effecting this compensation, in this case a useless compass was converted into one on which great reliance may be placed. But in cases of ships built with the keel on any other line than east and west, we must defer fixing on the exact distance of the compass from the vertical bar until we have the opportunity of determining the value of B in the steering compass, and of some other compass on board placed where the induction of upright iron is not likely to disturb it. Then by comparing B of the last-named compass with that of the steering compass, we can approximately determine the value of — B due to induction on vertical iron at the stern (foot-note to 61).

of deviation, it is done by bringing the compensating body nearer or removing it further from the compass. But the iron vertical bar is so fixed that this cannot be done; consequently, it becomes necessary that arrangements should be made to enable the adjuster to move the compass either nearer to or further from the vertical bar.

44. To determine the amount of deviation to be compensated by the vertical bar, the deviation should be observed by means of azimuths or amplitudes when the ship is passing the magnetic equator with her head either east or west by compass. But to render this observation satisfactory an opportunity should be taken both on her outward and homeward passage.* If, however, this cannot be effected, the coefficient B may be thus observed in some southern magnetic latitude as near as is practicable to the magnetic equator, and by calculation that amount of the change produced by a southern dip may be eliminated, and that produced by the northern dip be compensated in the manner already described, on her return to her port. The steering compass should then exhibit the same amount of attraction to the stern that it did, taking the mean of the experiments out and home, at the magnetic equator, where, on account of vertical iron being at right angles with the line of force of the earth's magnetism, no inductive magnetism exists in iron so situated.

45. Since, then, it is desirable that the commander of an iron ship should be able to ascertain when he is on the magnetic equator, he may by drawing a pencil through the following points, determine when he is on this line. To the east it commences on the African shore, opposite Fernando Po, lat. 4° N., long. 9° 15′ E., it crosses the equator at 4° 15′ E., the meridian of Greenwich at lat. 3° 20′ S., the meridian of 10° W. at lat. 8° 50′ S., 20° W. at lat. 12° 20 S′, 30° W. at lat. 15° S., and reaches the shores of South America at lat. 15° 20′ S., long. 40° 16′ W.†

Compensation of Semicircular Deviation.

46. The deviation from vertical iron being compensated, the deviation arising from sub-permanent magnetism must be neutralized by permanent magnets. The ship's head having been brought to the east or west to effect the compensation

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* If the magnetic attraction towards the stern is observed only on the outward passage, it would most probably be compounded with retentive magnetism (14), acquired by the ship's being kept south in her passage towards the equator. But since a contrary effect would result on her return, the mean of the two may very nealry approach the truth.

† Appended to the "Admiralty Manual" already referred to (foot-note 26), are three charts, on which are lines laid down of equal variation, dip, and horizontal force. The second may be advantageously employed in determining the value of — B in case it may be impracticable to observe it on the magnetic equator by making observations, out and home, on the line of equal magnetic dip north and south, and taking the mean.

described above (41), the ship's head is kept steady on the same point, to compensate + B or — B, as the case may be. This is effected by a magnet placed parallel to the fore and aft midship line of the ship, and also parallel to the ship's deck,* with the middle of the magnet's length in the vertical plane passing athwart-ship through the centre of the compass card. If this requirement be attended to under ordinary circumstances, it matters not whether the magnet is placed above, below, or on either side of the compass. The magnet must be moved nearer or further for trial, till the compass shows correct magnetic E. or W. If the ship's head was north or south whilst being built, probably two magnets will be required, when one should be placed on the starboard, and the other on the port side of the compass. If the north end of the needle is attracted towards the stern, that end of the magnet that repels the north end of the needle must be put towards the stern, but the contrary if the north end of the needle is drawn towards the bows. To compensate + C or — C it will be necessary to swing the ship's head to the north or south, and place magnets athwart-ship at right angles to the fore and aft midship line, and parallel to the ship's deck, with the middle of the magnet's length in the vertical plane passing longitudinally through the centre of the compass card. The distance of the magnet is to be determined by trial, till the compass shows correct magnetic N. or S. If it be + C that is to be compensated, that pole of the magnet that attracts the north end of the needle should be directed towards the port side, but if it be — C to the starboard side; in every other respect the same directions will be observed as given in compensating B. If C be large, two magnets, one before and one abaft the compass, may be necessary (Appendix C.)

Compensation of Quadrantal Deviation.

47. The semicircular magnetism being thus compensated, the ship's head should be swung to one of the four points courses, that is, to the N.E., S.E., N.W., or S.W., as the case may be, when the quadrantal deviation should be compensated. For many years this has been effected, by boxes fitted with iron chain attached to each side of the binnacle. The Compass Committee have, however, found that cast-iron correctors are preferable.

48. The Secretary of the Compass Committee (Mr. Rundell) has employed such cast-iron correctors, of two sizes; one 9 inches long by 3 inches in diameter, for correcting quadrantal deviation not exceeding 5°, the other 12 inches long by 3¼

* The Astronomer Royal (Professor Airy) has demonstrated that when a magnet is applied end on, for the compensation of deviation, it accomplishes that object properly only when it is on the same plane with the compass, that is, on the plane parallel to the ship's deck. If such magnet were placed in any other plane, it would produce a disturbing force when the ship heels. But no such disturbance is caused by a compensating magnet placed parallel to the ship's deck.

inches in diameter, for deviations not exceeding 8°. The ends of each corrector are made globular. The quadrantal correctors should be placed athwartship on the same horizontal plane as the needle, and one on either side of the compass, the distance is to be determined by trial, sliding the correcting iron nearer or further till the compass is correct, or, if chain boxes are employed, by putting more or less chain into the boxes, but the correction should not be nearer than $1\frac{1}{4}$ the length of the needle from the centre of the card. When the distance exceeds this proportional distance, the compensation is usually sufficiently correct for practical purposes, but not otherwise. On this account the use of long needles is adverse to good compensation. This adjustment is nearer perfect with a card having two needles than with a card having only one. Mr. A. Smith and Mr. F. J. Evans, of the Admiralty Compass Department, have shown that the compensation for deviation arising from horizontal iron is rendered perfect when a double-needle card is employed, in which the ends of the parallel needles are 60 degrees apart from each other.

49. Having approximately compensated B, C, and D, the value of the coefficients A, B, C, D, E, producing the remaining deviations, should be determined (53 to 57), which will enable the operator to reduce them; that which arises from B by means of the athwart-ship magnets, that from C by the fore and aft magnets, or from D by the cast-iron correctors or chain boxes (see Appendix C.) The coefficient A is generally allowed to remain uncompensated, but when large in amount it may be concealed (23) by moving the needles on the compass card, or, if preferred, the same result can be obtained by moving the lubber line to the right or left, as may be found necessary. +E may be compensated, by bringing the starboard corrector towards the stern (22), or the port iron corrector towards the bows, or − E may be compensated by bringing the starboard corrector towards the bows, or the port corrector towards the stern. The remaining deviations, if the operation for compensating has been properly conducted, will be very small. A table of them may, however, be formed by the same process as that which is used when no compensation is applied (51 to 64); also, see Appendix B.

50. The Astronomer Royal (Professor Airy) has recommended that an arrangement should be made to enable the captain to correct any changes in the deviation by bringing the compensating magnets nearer to or removing them further from the compass, as the case may require. The magnetic bearing of a visible point being known, or the magnetic bearing of a celestial body being computed before-hand for time observation, place the ship, by means of a dumb-card (foot note to 26), with her head correctly magnetic N. or S., and move the athwart-ship magnets till the compass shows N. or S., either exactly or with the same deviation as in port. Then, in like manner, place her head correctly magnetic E. or W., and move the fore and aft magnets until the compass shows east or west or the remaining deviation, if any is restored. In adjusting the *athwart-ship* magnets, care must be

taken that *the ship is on an even beam* * (67). By this means the same table of remaining deviations for each point of the compass may be used throughout the voyage, whilst the ship is on an even beam; whereas, had the magnets been so placed as to give no deviation on either of the two cardinal points on which observations had been made, the mariner would be left in doubt as to the amount of deviation when the ship's head was on any other point. For the above purpose an azimuth compass may be used, instead of a dumb-card, by stopping the card with the cardinal point, at which the ship's head is to be brought, at the lubber line. The late Mr. Gray introduced a neat arrangement of magnets to facilitate the above object.

Example: June 26, 1865, apparent time $5^h\ 36^m$ a.m., lat. 28° 30′ N., long. 30° 50′ W., variation 20° 20′ W.; before leaving port, with the ship's head north, correctly magnetic, the deviation was 1° W.; the north point of the card having been stopped at the lubber line, required the bearings of the sight-vane by card, for bringing the ship's head north, correctly magnetic, and the bearing of the ship's head that should be shown by the corrected compass.

Apparent time, $5^h\ 36^m$ a.m. Dec. 23° 30′ N. - - Latitude - - -	Arc I.	° ′ 46 29 log I. 10·3478. 28 30 N.
	Arc II.	74 59 log II. 0·0151.
	True bearing of sun	° ′ N. 66 30 E. 10·3629
	Variation, West -	20 20 to the right (29).
	The position of sight-vane	N. 86 50 E.

The compass, when adjusted, should show deviation 1° W.; that is, 1° to the right of north, or N. 1° E., when the sun is on the sight-vane of the dumb-card or the azimuth compass.

Construction of a Table of Deviation.

51. When it is thought desirable to allow a compass to remain uncompensated, and to construct a table of deviations for the correction of such compass, if practicable, this should be done by observing the deviation with the ship's head on each point of the compass (26); if not, on each alternate point; but when this even is not practicable a very approximate table

* An even beam is a term here employed to indicate that the ship neither heels to port or starboard, which by the mariner is usually called even keel. But this last term is also used to signify that the ship draws the same depth of water forward and aft. The use of the same expression to indicate two different conditions of the ship being calculated to cause confusion, the above term has been adopted.

may be constructed, by observing the deviation with the ship's head on the following eight points, by compass N., N.E., E., S.E., S., S.W., W., and N.W. From these observations the five coefficients A, B, C, D, and E, may be determined, and by means of these coefficients a deviation table* may be constructed for the ship's head on each point of the compass.

52. In constructing a deviation table, or in finding the value of the coefficients, the following rules should be adopted:—When easterly deviation is intended the plus sign (+) should be used, when westerly the sign (−) minus. Also in adding together several amounts plus and minus separately the sum of the minus must be subtracted from the sum of the plus, if the latter be the greater, or if the sum of the minus be greater, the sum of the plus must be subtracted from it, and the result must have the name of the greater, this being addition according to the rules of algebra, and will be so termed in the following rules, when the details of the process are not given. When, however, we subtract one quantity from another having the same sign, the difference will be the remainder, with the same sign if the less is taken from the greater, but the contrary sign when the greater is taken from the less. When the two quantities have different signs the remainder will be equal to the two quantities added together with the same sign as that of the quantity from which the given amount is subtracted thus,—22° 24′ less −11° 0′ is −11° 24′, but − 11° 0′ less − 22° 24′ is + 11° 24′, and − 11° 0′ less + 11° 24′ is − 22° 24′, and + 11° 24′ less − 11° 0′ is + 22° 24′.

Determination of the Coefficients A, B, C, D, E.

53. To find the value of A add together algebraically (52) the four deviations determined, with the ship's head on the cardinal points by compass, and divide the sum by the number of observations, and the result will be the value of A.

EXAMPLE.—The error of the compass, the deviation table of which is given (58), was observed on the four cardinal points (51), required the value of A.

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* A very simple method of determining the deviation on each point of the compass as well as to distinguish deviations with ship's head correct magnetic, from deviations ship's head by compass (34), is by means of Napier's Graphic Method, which is now included in the "Admiralty Manual" (see foot note 26), which requires no calculation but a free hand to a moderate extent. Diagrams are provided at a very low price by the Admiralty. On this diagram each observed deviation is marked by a cross on the part of the diagram which represents the direction of the ship's head by compass or correct magnetic, as the case may be, then with a pencil draw a flowing curve through each cross. Then in the manner fully described in the manual, the deviation with the ship's head on any point or degree correct magnetic or by compass may be determined.

The coefficients may also be computed, and a table of errors constructed by means of tables also now included in the "Admiralty Manual" already referred to (foot note 26). Blank forms are also published to facilitate the computation of deviations; which method is the contrivance of Archibald Smith, Esq., M.A., F.R.S.

North	− 7° 10′	South	+ 2° 10′
East	− 18 20	West	+ 17 20
	− 25 30		+ 19 30
	+ 19 30		
The number of observations	4)− 6 0		
	A = − 1 30		

54. To find B add together the deviation observed with the ship's head east and west by compass, reversing the sign of the latter, and half the sum will be the value of B.

The deviation of the compass before referred to (58) was at east − 18° 20′, and at west + 17° 20′, reversing the sign of the latter we have—

	− 18° 20′	
	− 17 20	sign reversed
sum	− 35 40	
½ sum	− 17 50	= B

55. To find C add together the deviation observed when ship's head was north and south by compass, reversing the sign of the latter, and half the sum will be the value of C.

The deviation of the same compass (58) when the ship's head was north, was − 7° 10′, when south + 2° 10′, reversing the sign of the latter we have—

	− 7° 10′	
	− 2 10	sign reversed
sum	− 9 20	
½ sum	− 4 40	= C

56. To find D add together (52) the deviation observed with ship's head N.E., S.W., S.E., and N.W., by compass, reversing the signs of the last named two, and divide the sum by four.

The deviation of the same compass (58) was N.E. − 11° 45′, S.W. + 20° 5′, and S.E. − 16° 29′, and N.W. + 2° 9′.

N.E.	− 11° 45′	S.W.	+ 20° 5′
N.W.	− 2 9	S.E.	+ 16 29
	sign reversed		sign reversed
	13 54		+ 36 34
			− 13 54
			4) 22 40
			+ 5 40 = D

57. To find E add together (52) the deviation ship's head north and south, and that observed when east or west, reversing the signs of the last-named two, and divide the sum by four.

The deviation of the same compass (58) was at north −7° 10′, at south + 2° 10′, and east − 18° 20′, and west + 17° 20′.

North	−	7 10	South	+	2 10
West	−	17 20 sign reversed	East	+	18 20 sign reversed
	−	24 30		+	20 30
	+	20 30			
4)	4	0			
	−	1 0 = E			

58. The following is a Table of deviations for the "City of Baltimore's" standard compass uncompensated, and the amount of deviation produced by each coefficient with the ship's head on each point of the compass.

Ship's Head by Compass.	Coefficients. A = −1° 30′	B = −17° 50′	C = −4° 40′	D = +5° 40′	E = −1° 0′	Total Deviation.	Ship's Head, Correct Magnetic.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′
North	−1 30	0 0	−4 40	0 0	−1 0	− 7 10	N. 7 10W.
N. by E.	−1 30	− 3 29	−4 35	+2 10	−0 55	− 8 19	N. 2 56E.
N.N.E.	−1 30	− 6 50	−4 19	+4 0	−0 42	− 9 21	N.13 9E.
N.E. by N.	−1 30	− 9 54	−3 53	+5 14	−0 23	−10 26	N.23 19E.
N.E.	−1 30	−12 37	−3 18	+5 40	0 0	−11 45	N.33 15E.
N.E. by E.	−1 30	−14 50	−2 36	+5 14	+0 23	−13 19	N.42 56E.
E.N.E.	−1 30	−16 29	−1 47	+4 0	+0 42	−15 4	N.52 26E.
E. by N.	−1 30	−17 29	−0 55	+2 10	+0 55	−16 49	N.61 56E.
East	−1 30	−17 50	0 0	0 0	+1 0	−18 20	N.71 40E.
E. by S.	−1 30	−17 29	+0 55	−2 10	+0 55	−19 19	N.81 56E.
E.S.E.	−1 30	−16 29	+1 47	−4 0	+0 42	−19 30	S. 87 0E.
S.E. by E.	−1 30	−14 50	+2 36	−5 14	+0 23	−18 35	S. 74 50E.
S.E.	−1 30	−12 37	+3 18	−5 40	0 0	−16 29	S. 61 29E.
S.E. by S.	−1 30	− 9 54	+3 53	−5 14	−0 23	−13 8	S. 46 53E.
S.S.E.	−1 30	− 6 50	+4 19	−4 0	−0 42	− 8 43	S. 31 13E.
S. by E.	−1 30	− 3 29	+4 35	−2 10	−0 55	− 3 29	S. 14 44E.
South	−1 30	0 0	+4 40	0 0	−1 0	+ 2 10	S. 2 10W.
S. by W.	−1 30	+ 3 29	+4 35	+2 10	−0 55	+ 7 48	S. 19 3W.
S.S.W.	−1 30	+ 6 50	+4 19	+4 0	−0 42	+12 57	S. 35 27W.
S.W. by S.	−1 30	+ 9 54	+3 53	+5 14	−0 23	+17 8	S. 50 53W.

Ship's Head by Compass.	Coefficients.						Ship's Head, Correct Magnetic.
	A = −1° 30′	B = −17° 50′	C = −4° 40′	D = +5° 40′	E = −1° 0′	Total Deviation.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′
S.W.	−1 30	+12 37	+3 18	+5 40	0 0	+20 5	S. 65 5 W.
S.W. by W.	−1 30	+14 50	+2 36	+5 14	+0 23	+21 33	S. 77 48 W.
W.S.W.	−1 30	+16 29	+1 47	+4 0	+0 42	+21 28	S. 88 58 W.
W. by S.	−1 30	+17 29	+0 55	+2 10	+0 55	+19 59	N. 81 16 W.
West	−1 30	+17 50	0 0	0 0	+1 0	+17 20	N. 72 40 W.
W. by N.	−1 30	+17 29	−0 55	−2 10	+0 55	+13 49	N. 64 56 W.
W.N.W.	−1 30	+16 29	−1 47	−4 0	+0 42	+ 9 54	N. 57 36 W.
N.W. by W.	−1 30	+14 50	−2 36	−5 14	+0 23	+ 5 53	N. 50 22 W.
N.W.	−1 30	+12 37	−3 18	−5 40	0 0	+ 2 9	N. 42 51 W.
N.W. by N.	−1 30	+ 9 54	−3 53	−5 14	−0 23	− 1 6	N. 34 51 W.
N.N.W.	−1 30	+ 6 50	−4 19	−4 0	−0 42	− 3 41	N. 26 11 W.
N. by W.	−1 30	+ 3 29	−4 35	−2 10	−0 55	− 5 41	N. 16 56 W.

Construction of a Deviation Table for all Bearings, by use of the Coefficients A, B, C, D, E.

59. The coefficients being given, a table of deviations may be constructed for every point of the compass, by finding the deviation due from each coefficient, with the ship's head by compass towards either or each point, that is thought necessary. For this purpose coefficient A with its sign, being a constant quantity, is due alike to each point of the compass.

60. To determine the deviation due to B with the ship's head on any given point, reduce the minutes to tenths of a degree by dividing them by six, and placing this to the right of the number of degrees we have the number of tenths. Coefficient B in the table of deviations given (58) is −17° 50′, and is therefore approximately − 178 tenths of a degree. Enter a traverse table (Table I. of Norie's) with the tenths of a degree in the distance column, and the given number of points from the north or south by compass at the top or bottom of the table, and the corresponding departure will be the number of tenths of a degree due to B when the ship's head is on the given point. To determine whether it should be easterly or westerly, the sign will be the same as that of the coefficient, if the given point is east of north or south, but if west it must have the contrary sign. If we desire to know the deviation with ship's head by compass N.N.E., we enter traverse table with 178 in the distance column, and two points at the top; the departure, 68 tenths of a degree = 6° 48′ is the deviation arising from B on this point, and is − 6° 48′, having the same sign as the coefficient, according to the above rule.

61. In the same manner the value of C on any given point may be determined (72), with this difference, that the deviation

due from C must be taken out from the latitude column, instead of that of the departure, as in the case of B, and it has the same sign as the coefficient if north of the east and west points, but a contrary sign if south of these points. The coefficient C (58) is $-4^\circ 40' = 47$ tenths of a degree nearly; this at N.N.E. gives in latitude column 43 tenths or $-4^\circ 18'$, having the same sign as the coefficient, because the ship's head is north of east.*

62. To determine the deviation due to D for any given point, with this coefficient reduced to tenths of a degree, enter the table as before described, but at top or bottom with twice the number of points that the ship's head is from either of the cardinal points. and the departure will give the number of tenths of a degree due to D. This will have the same sign as the coefficients in the quadrants from north to east, and from south to west, but a contrary sign from east to south and from west to north. Thus the coefficient D (58) being $+ 5^\circ 40' = 57$ tenths at N.N.E., being two points from north, we enter traverse table with four points at the top, and the departure will give 40 tenths $= + 4^\circ$, having the same sign as coefficient according to the above rule.

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* Let t represent the total horizontal sub-permanent magnetism of the ship, in the term of the earth's horizontal magnetic force, and L the inclination of the line of this magnetic force to the fore and aft midship line of the ship. When the ship is first launched L will be the line on the ship's deck which, during the time the ship was being built, was cut by the vertical plane that intersects the earth's line of force (7). Having determined the value of B (54) and C (55),

$$t = \sqrt{C^2 + B^2}; \text{ and}$$

$$\tan L = \frac{B}{C}.$$

But for the mariner the most simple solution of these problems will be by means of the traverse Table II. of Norie's. Having reduced the degrees and minutes into tenths of a degree (60), find in the latitude column the number agreeing with B, which answers to the number in the departure column which agrees with C, then in the distance column will be found the maximum deviation, resulting from sub-permanent magnetism, in tenths of a degree, the sine of which is equal to t; also the course is equal to L. It is supposed in this statement that the semicircular disturbance is wholly caused by the ship's sub-permanent magnetism (16). This is true when the compass is not placed near a vertical iron stanchion or other vertical iron (38), or when a vertical rod has been introduced (41), as proposed by Mr. Rundell, to neutralize the effects of such vertical iron.

In the case of the "Simla" (Appendix D.) we find B + 46 tenths of a degree, and C − 261 tenths. These will be found in the latitude and departure columns, answering to 265 in the distance column, in Table II. page 26 of Norie's "for 80 degrees." The natural sine of 26° 30′ (265 tenths of a degree) is ·446198 = t, and L = 80° − C indicates that the ship's head was westerly whilst being built, + C easterly, − B northerly, + B southerly; consequently the "Simla's" was S. 80° W., when she was built, if the B and C were the result of sub-permanent magnetism alone, and had not undergone any change since the ship was launched (12).

On the other hand, knowing the direction of the ship's head, correct magnetic, at the time she was built, we can determine the ratio that the sub-permanent magnetism producing B bears to that producing C, the latter being to the former as the sine is to the cosine of the inclination of the fore and aft midship line of the ship to the magnetic meridian. Or using the traverse table we enter it as a course with the number of degrees which the fore and aft midship line of the ship inclines to the magnetic meridian when the ship was built, then answering to the value of C in tenths of a degree in the departure column, in the latitude column we find the value of B, which subtracted algebraically (52) from the B observed will give the approximate value of the induced magnetism of the vertical iron at the stern that should be compensated by a vertical iron bar before the compass (41).

63. In like manner we find the value of E, only the result must be taken from the latitude column, instead of that of the departure. In the quadrants between N.E. and N.W., or S.E. and S.W., the sign is the same as that of the coefficient, but between N.E. and S.E., or S.W. and N.W., it has the contrary sign. Coefficient E being $-1^\circ\ 0'$ we enter the table with 10 distance and for N.N.E., being two points from north we enter the table with four points and take out latitude 7 = $-\ 0\ 42'$, the sign being of the same name as the coefficient according to the above rule.

64. Having the deviation due to each coefficient, we sum them up algebraically (52) thus,—

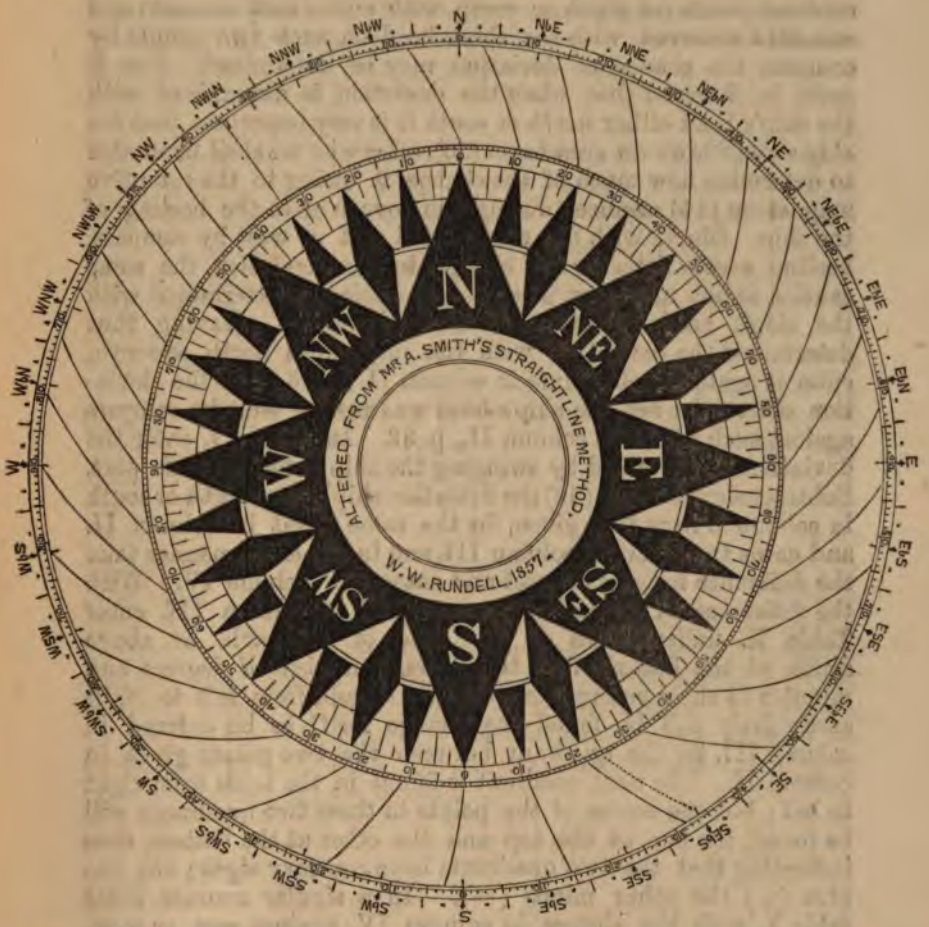
	° ′	° ′
N.N.E.	$-$ 1 30 = A	$+$ 4 0 = D
	$-$ 6 48 = B	
	$-$ 4 20 = C	
	$-$ 0 42 = E	
	$-$13 20	
	$+$ 4 0	
	$-$ 9 20 = Deviation ship's head N.N.E. by compass.	

65. In case a compass is allowed to remain uncompensated, it has a different amount of deviation with a ship's head on any given point by compass, and the same point correct magnetic; in such cases it is necessary that the mariner should understand some method of reducing a table constructed for the purpose of correcting ship's courses steered to a table for shaping a course (34). This may be effected by means of Napier's Graphic Method, (foot-note to 51). There is, however, another method, which the masters of iron ships sailing from the port of Liverpool generally prefer. It consists of a compass-card within a circle representing the correct magnetic points. Having determined the deviation for ship's head by compass, apply such deviation to each point, and draw a line from the point of the inner compass, to the corrected bearing of the ship's head on the outer circle. Thus suppose when the ship's head is S.W. by compass the deviation is $+20^\circ\ 5'$, this applied to S. 45° W. gives S. 65° 5′ W.; draw a line from S 45 W. on the inner compass to S. 65° 5′ W. on the outer circle, and so on with each point. Thus from the first and last columns of 58 the following deviation card is constructed. Then if when shaping her course we find that her head should be S.E. by S. correct magnetic, we must steer the course to which a line leading in the same direction as those drawn on the card, and this will be from S.E. by S. to S. 24° 30′ E., on the inner compass, which is to be the course steered by compass.

DEVIATION CARD

For the Standard Compass of the "City of Baltimore," swung at Liverpool, June the 8th and 9th, 1857.

The outer graduated circle is intended to represent the correct Magnetic Points of the horizon.



The inner graduated circle is intended to show Ship's Head "by Compass," and the lines leading from it to the outer circle indicate the corresponding direction of Ship's Head "Correct Magnetic" for each point of the Compass.

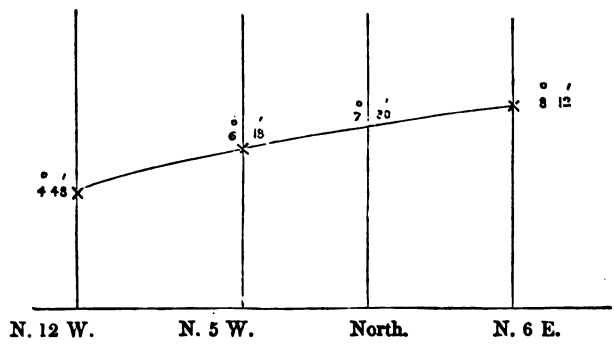
66. It has been shown that neither compensation nor a table of deviations can be relied on with safety except in about the same magnetic latitude (37) as that in which the ship was swung. And even in returning to the same port after a long voyage, if the ship's head has been kept for a long period in nearly one direction (13 and foot note) the magnetic condition of the ship frequently undergoes so great a change as to render it dangerous

to rely on a table of deviations constructed previously to leaving port. It is therefore very desirable that the master in command of an iron ship should be enabled to form an approximate estimate of the change in the deviation both previously to his arrival at a distant port and before entering the channel on his return after a long voyage. The change of deviation that takes place in either case is principally in B (37) and C (13) and if the ship's head can be brought steadily on any two adjacent cardinal points (as north or south with either east or west) and azimuths observed with the ship's head on such two points by compass the change of deviation may be determined. But it must be observed that when the deviation is determined with the ship's head either *north* or *south* it is very important that *the ship should be on an even beam* (50), otherwise we shall be unable to determine how much of the change is owing to the retentive magnetism (14) acquired during the voyage or to the heeling of the ship. Since, with the ship's head east or west by compass, heeling causes little or no change in the deviation, the same caution is not necessary when the deviation is determined with the ship's head in either of these directions. Having thus determined the deviations with the ship's head north or south, enter it against such points in column II.; also enter the deviation observed when the ship's head was east or west by compass against such point in column II., p. 32. In column I. enter the deviations determined by swinging the ship before she left port. Subtract algebraically (52) the deviation ship's head north or south in column I. from that given for the same point in column II. and enter the result in column III. and in the same manner take the difference for east or west and enter it in column IV. With the difference of deviation thus entered in column III. enter Table X. under north at the head of the table or above south at the bottom, find the nearest number of degrees and minutes to those entered in column III. and from left to right successively will be found the change for C, to be entered in column III. for the quadrant between the two points given in column II. The next quadrant is found in the table from right to left; but the names of the points in these two quadrants will be found, the one at the top and the other at the bottom, thus indicating that the two quadrants have contrary signs; the one plus (+) the other minus (−). In a similar manner enter table X. with the change in column IV. against east or west, as the case may be, and enter in the same column the changes given against each point in the two quadrants for which the change of B is entered, but in this column the signs for every point in these two quadrants will be the same, which circumstance is indicated by the names of the points in both quadrants being given either all at the top or all at the bottom of table X. Next add together algebraically (52) the change of C and B against each point in columns III. and IV. and enter the result in column V., which will be the total change of deviation from that given in column I. for two quadrants or sixteen points; for the other sixteen points

enter successively the same amount of change as that given for the other two quadrants, but with the contrary sign. Add together algebraically the deviation given in column I. and the total change in column V. for each point of the compass, and enter the result in column VI. This would have been the table of deviation applicable for use whilst the "Royal Charter" was at Melbourne.

It may probably occur that it is impracticable to take an azimuth with the ship's head exactly on the cardinal point. In such case two or more observations may be taken with the ship's head near such point and the deviation at the point required may then be determined by means of Napier's Graphic Method. (See foot note to 51).

In case no blank form is available draw a horizontal line and another line perpendicular to the former. Should we desire to determine the deviation with the ship's head on a cardinal point, having determined the scale of equal parts to be adopted, say an eighth of an inch to a degree, mark off on the horizontal line from the point touched by the perpendicular, the number of eighths of an inch that agrees with the number of degrees the ship's head was from the cardinal point at the time the several deviations were determined, these distances or stations being taken to the right or left of the first perpendicular, according as the ship's head is right or left of the cardinal point. At each of these stations draw a perpendicular, and on these perpendiculars lay off by the same scale of equal parts distances from the horizontal line proportioned to the deviations observed when the ship's head was in the direction corresponding to the stations respectively. Now draw a curve freely through the points marking these distances, and the distance above the horizontal line at which this curve cuts the first drawn perpendicular will measure the true deviation with the ship's head on the cardinal point. Example, the deviation observed with the ship's head N. 6 E. was 8° 12′, N. 5 W. was 6° 18′, and when N. 12 W. was 4° 58′; by the following diagram, constructed according to the directions given above, it is shown that with ship's head north the deviation would be 7° 30′.



DEVIATIONS of the STANDARD COMPASS of the ROYAL CHARTER at LIVERPOOL 1856, and at MELBOURNE, May 1856.

Ship's Head by Standard Compass.	I. Deviation at Liverpool, January 1856.	II. Observed Deviations at Melbourne. Ship's Head North and East.	III. II. less I. at North at other Points from Table X. C.	IV. II. less I. at East at other Points from Table X. B.	V. Sum of III. and IV. — Total Change of Deviation.	VI. Sum of I. and V. — Deviation at Melbourne, January 1856.
	° ′	° ′	° ′	°	° ′	° ′
North	−22 24	−11 0	+11 24	+ 0 0	+11 24	−11 0
N. by E.	−20 42		+11 17	+ 0 23	+11 40	− 9 2
N.N.E.	−17 30		+10 37	+ 0 46	+11 23	− 6 7
N.E. by N.	−14 24		+ 9 34	+ 1 7	+10 41	− 3 43
N.E.	−11 6		+ 8 8	+ 1 25	+ 9 33	− 1 33
N.E. by E.	− 8 6		+ 6 23	+ 1 40	+ 8 3	− 0 3
E.N.E.	− 6 18		+ 4 24	+ 1 51	+ 6 15	− 0 3
E. by N.	− 4 18		+ 2 15	+ 1 58	+ 4 13	− 0 5
East	− 3 30	− 1 30	0 0	+ 2 0	+ 2 0	− 1 30
E. by S.	− 3 0		− 2 15	+ 1 58	− 0 17	− 3 17
E.S.E.	− 0 30		− 4 24	+ 1 51	− 2 33	− 3 3
S.E. by E.	+ 1 30		− 6 23	+ 1 40	− 4 43	− 3 13
S.E.	+ 3 30		− 8 8	+ 1 25	− 6 43	− 3 13
S.E. by S.	+ 6 42		− 9 34	+ 1 7	− 8 27	− 1 45
S.S.E.	+11 0		−10 37	+ 0 46	− 9 51	+ 1 9
S. by E.	+15 0		−11 17	+ 0 23	−10 54	+ 4 6
South	+19 0				−11 24	+ 7 36
S. by W.	+21 48				−11 40	+10 8
S.S.W.	+23 42				−11 23	+12 19
S.W. by S.	+23 42				−10 41	+13 1
S.W.	+21 42				− 9 33	+12 9
S.W. by W.	+18 30				− 8 3	+10 27
W.S.W.	+12 36				− 6 15	+ 9 21
W. by S.	+ 8 42				− 4 13	+ 2 29
West	+ 4 18				− 2 0	+ 2 18
W. by N.	− 2 30				+ 0 17	− 1 13
W.N.W.	− 8 12				+ 2 33	− 5 39
N.W. by W.	−13 54				+ 4 43	− 9 11
N.W.	−18 24				+ 6 43	−11 41
N.W. by N.	−21 54				+ 8 27	−13 27
N.N.W.	−24 6				+ 9 51	−14 15
N. by W.	−23 42				+10 54	−12 48

Effects of Ship's Heeling.

67. All previous observations refer exclusively to deviations of the compass whilst the ship is on an even beam (foot note to 50). A table of errors, however correctly determined, is of no value if the ship heel over, unless allowance be made for the disturbance thus occasioned. We have hitherto only regarded the horizontal force of the ship's sub-permanent magnetism, and have resolved this force into two, B towards the bows (plus or minus), and C towards the starboard side (plus or minus). But when we consider the effect of heeling we have another force, plus or minus vertical,* to be taken into consideration, the poles of the ship's magnetism seldom being on the horizontal plane. In most instances the pole of the ship's magnetism that attracts the north end of the needle is below the horizontal plane; but ships built with their heads south, as far as experience has taught us, have the repelling or minus pole below the needle. Now, whilst any of the vertical part of polar magnetism remains below the compass, it produces no deviation, but when, by the ship's heeling, it is brought out to starboard or port, it produces a C. If it is plus vertical, the C produced will be plus when the ship heels to port and minus when the ship heels starboard, but the contrary with ships having a minus force below the compass. If we express the intensity of the ship's vertical sub-permanent magnetism in the terms of the earth's horizontal magnetic force, the horizontal modulus (foot-note to 8) of this disturbing force by heeling will be vertical modulus multiplied by the natural sine of the ship's heel, and the maximum disturbance will be with the ship's head north or south by compass, but when the ship's head is east or west it disappears, since it is a coefficient C, which is always thus produced by heeling.

68. There is another source of error arising from a ship's heeling. Each horizontal bar of iron produces a modulus of deviation in proportion to its inclination towards the line of the earth's magnetic force (7, 8, and foot-note p. 34). We have shown that horizontal iron produces quadrantal deviation (8), and that vertical iron produces polar deviation, but heeling causes the iron which produced D whilst the ship is on an even beam to give a C also when the ship heels over, because that which was previously horizontal now partakes of the nature of vertical as well as of horizontal iron, and the C thus produced (with the dip 70° and heel 10°) will be nearly as great as the original D, the D being only reduced fifteen thousandth-parts of its original value.

But the D which produces this C by heeling is considerably greater than the D exhibited in discussing the deviations observed in swinging a ship on even beam. In the case of the table of

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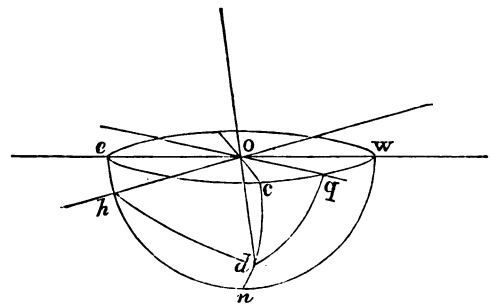
* The term vertical is here used to describe a line perpendicular to the ship's deck, whether the ship is upright or otherwise.

errors given (58), D is stated to be + 5° 40′; but this apparent D + 5° 40′ is made up of two values, D + 9° 30′ from athwartship iron and D − 3° 50′ from fore-and-aft iron, the latter compensating 3° 50′ of the former whilst on even beam. But fore-and-aft iron is not disturbed from its horizontal position by heeling, consequently the athwartship beams then produce their full influence in disturbing the compass, which in the case referred to (58) would produce C = + 9°, but if the D = + 5° 40′* had



* Let *e*, *w*, *n*, represent a vertical plane at right angles to the magnetic meridian, *n* being the nadir. Let *q* represent a point of the horizon, four points from the magnetic meridian, and *c d*, the dip. All iron beams receive inductive magnetism in proportion as they approach parallism with *o d*, and consequently when the arc of inclination is 0°, the inductive force is a maximum, that is the inductive magnetism of any bar is the greatest that it is capable of receiving from the earth in the given locality. To determine the angle *d o q* between the line of force and horizontal iron inclined at 45° to the magnetic meridian, we have the spherical triangle *q c d*, which is a right angle, *q c* = 45°, and *c d* the magnetic dip, being the arc of inclination of a horizontal bar in the direction of the magnetic meridian, to the line of the earth's magnetic force

$$\cos d\,q = \cos c\,d \,.\, \cos c\,q \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

the arc *d q* measuring the inclination of *o q* to the line of force *o d*.

Let *m* be the induced magnetic force when the bar is in the line of force or coincident with *o d*; then the induced magnetic force in the bar when it is inclined at the angle *q o d* to the line of the force will be

$$m \,.\, \cos d\,q = m \,.\, \cos c\,d \,.\, \cos c\,q \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Calling this disturbing force *t*, and the directive horizontal force of the earth's magnetism T, if coefficient D be the deviation when *t* acts at an angle *c o q* (arc *c q*) by resolving these forces in a direction at right angles to the needle we have

$$T \,.\, \sin D = t \,.\, \sin c\,q\,;$$

but by (2), $t = m \,.\, \cos c\,d \,.\, \cos c\,q$; $\therefore T \,.\, \sin D = m \,.\, \cos c\,d \,.\, \cos c\,q \,.\, \sin c\,q$;

$$\therefore m = \frac{\sin D \cdot T}{\cos c\,d \cdot \frac{1}{2} \sin (2 \cdot q\,c)} = \frac{2 \sin D}{\cos c\,d \cdot \sin (2 \cdot c\,q)} \cdot T\,;$$

and in the case above (68) where D = 9° 30′, *c d* = 70° and *c q* = 45°

$$m = \frac{2 \cdot \sin 9° 30'}{\cos 70°} \cdot T = \cdot 9651 \cdot T;$$

and if T = 1, then *m* = ·9651, the modulus of the magnetism of the earth induced in the iron parallel to the deck of the ship, if it were also parallel to the line of force *o d*.

Having determined the value of *m*, to find the coefficient C produced by heeling, we have the spherical right angled triangle *d n h*, of which the angle *d n h* is the right angle, to find the angle of inclination to *d o* of an iron bar at right angles to the meridian and inclined 10° to the horizontal plane. $\cos h\,d = \cos d\,n \,.\, \cos h\,n$, *h d* being the arc of inclination; sin. C = *m* . cos *d n* . cos *h n* = ·9651 . cos 20° . cos 80° = sin 9° 4′ = C. But since the dip decreases as we proceed towards the magnetic equator, and *c d* decreases at the same time, consequently the effects of heeling on horizontal iron must be reduced. This error, from heeling, by horizontal iron therefore decreases as we proceed towards the magnetic equator, and will be reversed in the southern hemisphere.

been compensated by iron correctors the C from heeling would have been reduced to 3° 20′ (32 and Appendix D).

69. In all latitudes a positive force below the compass, if arising from sub-permanent magnetism, produces + C heeling to port and — C heeling starboard, and in north latitudes + D produces the same results. But horizontal iron can produce no C by heeling on the magnetic equator, and gives a C of a contrary sign by heeling in southern latitudes; so that with the positive pole of sub-permanent magnetism below the compass and + D we have the sum of the disturbances by these causes in north latitude and their difference in south. In the case of the "Simla," according to the report of Captain Williams, in south latitudes the inductive influence prevailed, and the compass had a contrary disturbance from heeling to that observed when the heeling experiments were made at Liverpool; but in the "Recruit" and "Bloodhound" (as also recorded in the third report of the Liverpool Compass Committee, p. 61,) the sub-permanent minus force below the compass was greater than the plus force produced by induction in horizontal iron. That athwartship iron exercised an influence on the compass to a greater extent on board the "Simla" appears very probable from the fact that coefficient D of the standard compass of the latter ship was + 5° 8′, while that of the "Recruit" was only + 3° 0′, and that of the "Bloodhound" + 3° 15′. It is, however, probable that the magnetic force below the compass is partly due to retentive magnetism (14), and this would combine with induction of athwartship iron in the case of the "Simla" to reverse the effect of heeling in the southern hemisphere. In some cases the deviation from heeling has amounted to as much as two degrees for each degree of heel of the ship, that is, without altering the real direction of the ship's head, the apparent alteration by compass has amounted to 40° by heeling the ship from 10° to port to 10° starboard.*

70. It appears from the experiments hitherto made, that the effect produced by heeling is also influenced by the direction in which the ship was built. The following is the change of C in the case of six ships which have been heeled, which appears

* It follows that when the amount of deviation is changed by the rolling of the ship the compass is liable to be very unsteady, especially when the ship's head is north or south nearly. The amount of this unsteadiness will depend on two conditions:—first the amount of the change of deviation arising from any number of degrees of heeling, and secondly from the isochronism or otherwise that exists between the periods of the vibration of the needle and the rolling of the ship. Taking this latter condition into consideration, when very great inconvenience is experienced, arising from the unsteadiness of the compass, the card should be changed, since either a more sluggish or more active needle may probably be in less unison with the rolling of the ship. But since with the ship's head in one direction the activity of the needle will be much greater than when on another point (16), a card which has been the most unsteady in one case will probably be the most steady under other circumstances. This evil is however avoided by compensating with a vertical magnet (see Appendix D).

to support the hypothesis that ships built in the northern hemisphere with their heads north are most affected, and that those built with their heads S.E. or S.W. the least affected, and those with their heads nearly south have a minus vertical pole below the compass; but heeling experiments have hitherto not been sufficiently numerous to establish this hypothesis. The following gives the change of deviation of the standard compasses of the six ships here referred to from heeling, from 10° port to 10° starboard.

Name of Ship.	Direction of Head when built.	Heel Port.	Heel Starboard.	Change of Coefficient C.
		° ′	° ′	° ′
City of Baltimore -	West of North	+12 48	−23 4	−35 52
Aphrodita - -	East	+33 33	+ 2 58	−30 35
Slieve Donard -	E. 30 S.	+ 3 27	+ 2 12	− 1 15
Recruit - - -	East of South	+ 1 49	+14 2	+12 13
Bloodhound - -	West of South	− 4 55	+ 1 10	+ 6 5
Simla - - -	West	− 2 43	−23 29	−20 46

The deviation from heeling caused the north end of the needle on board the "City of Baltimore," Aphrodita," and "Simla," to be drawn considerably towards the upper or windward side, and in the "Slieve Donard" slightly so, whilst the needles of the "Recruit" and "Bloodhound" were drawn towards the lower side.*

71. The two principal causes of disturbance of the deviation of the compass are those already described, vertical sub-permanent

* The writer has found that in all cases of an uncompensated compass in which the vibration experiments have been tried (Appendix B), when the vertical force below the compass is reduced to nine-fourteenths of that observed on shore, the compass will not be considerably affected by heeling. If this suggestion be adopted it should be confined to those ships alone that are destined for voyages nearly within the same magnetic latitudes, such as to the United States, or to Canada. For if we compensate the disturbance from heeling which arises both from sub-permanent and inductive magnetism by permanent magnets, we should gain an advantage in these latitudes at the expense of aggravating the evil in the southern hemisphere. No approximate theory can yet be propounded for the compensation of a compass against the disturbance of the deviation by heeling in both hemispheres, because no data at present exist to determine how much of the magnetic force below the compass results from sub-permanent, or how much from retentive magnetism (14). To compensate the latter by permanent magnets in this hemisphere would aggravate the evil in the southern latitudes, unless the compensating vertical magnet is adjusted from time to time (see Appendix D).

magnetism below the compass, and the change in the inductive magnetism in transverse horizontal iron. But there are other causes that to a smaller degree either increase or reduce the effect caused by these. Vertical iron with its upper end below the compass, such as iron pillars, produces a − or + C, according as the ship heels to starboard or port, also a − D in both cases, and water-tight compartments produce a compound result of vertical and athwartship iron, and iron masts, funnels, and all other descriptions of iron having the lower part below the level of the compass and the upper above, by heeling produce + D.

72. It is seldom that an iron ship is swung for a deviation table, except when upright. This table is of little value when the ship heels either to port or starboard, since with the ship's head north or south by compass the deviation is either increased or decreased, in some cases to the amount of two degrees for each degree the ship heels, whilst in other cases little or no disturbance is thus occasioned (70). If practicable, therefore, the ship should be heeled both to port and starboard, and the change in the deviation produced by heeling should either be approximately compensated by a vertical magnet (see Appendix D.), or a table of the change in the deviation should be constructed. This is especially desirable in steamers engaged in the North American lines, since during their voyages the magnetic latitude is not changed to an amount which would render either compensation or a table of the change of deviation from heeling dangerously in error on approaching the American coast. And if the vertical magnet be adjusted from time to time (see Appendix D.), or the table of change of deviation corrected by observation (74), either would be valuable even for ships proceeding to the southern hemisphere. But in suggesting the use either of the compensation by the vertical magnet or of approximate tables the mariner should be cautioned not to depend on them within a half point; using such tables he should, if practfcal, so shape his course that even a point of error should not place him in danger.

73. The change of deviation from heeling, whether from subpermanent or inductive magnetism, principally affects the value of C (67, 68), consequently we can obtain an approximate table of deviations for the ship when heeling to port and starboard from the table constructed when the ship was swung upright, together with one or two observations made with her head within a point or two of north or south, and heeling considerably to port or starboard—thus: In a table constructed similarly to the one following, in column III. enter against each point the deviation for the ship upright, and enter the change in the deviation (that is, the deviation when heeling, less algebraically (52) the deviation on the same point ship upright) in column II. if the heel be to port, or in column IV. if the heel be to starboard. Then enter Table X. in line C and under

or above the point corresponding to the bearing of the ship's head where the deviation was observed when the ship was heeling, find the quantity nearest to the change from heeling, and in the same line right and left will be found the change of deviation for each point in the quadrant, and in which the sign (+ or −) will be the same as the change observed. The amount of change for each point in the other three quadrants is also given, but it must be observed that if any point named at the head of the table has a plus sign, all the others are plus, or if one has a minus sign, all the other points between the same lines are minus. The same rule will hold with the points between the lines at the bottom of the table; but those at the head of the table will have an opposite sign to those at the bottom. Having thus filled up the column II. or IV., as the case may be, and having placed the proper sign against each, fill up the other column (IV. or II.) with the same amount of change, reversing the sign. Add together algebraically (52) II. and III., and place the result in column I., and add together in like manner III. and IV. and place the result in column V.; the former will be the deviation table for a heel, for the given number of degrees, to port, and the latter for a starboard heel.

74. It is convenient to tabulate deviations for ten degrees of heel and also the change of deviation for ten degrees with the ship's head on each point as in the following table. The amount of change for ten degrees can be determined approximately from an observation made when the ship has any other amount of heel either by the simple rule of proportion or by dividing the number of tenths of a degree by the number of degrees that the ship heels. Suppose, for instance, that a ship with her head S.S.W. by compass, heels four degrees to starboard by clinometer and the deviation was observed to be + 20° 45′ instead of +13° 57′ which was the deviation with the ship's head on the same point, but upright, when swung for a deviation before she left port. The difference here shown, from heeling four degrees in a two point course is plus 6° 48′= (+6°. 8) Divide the number of tenths of a degree (+68) by the number of degrees heel (4) the result (+17) will be the number of degrees change in the deviation for a heel of ten degrees.

The following is a table of deviation for the standard compass of the "City of Baltimore." Column III. is the deviation determined by swinging the ship on an even beam June 18th, 1857. Columns I. and V. show the deviations when she is heeling to port and starboard, and were computed from column III. by means of one observation made with the ship's head E.S.E. when she was heeling to starboard. Columns II. and IV. show the changes of deviation.

Ship's Head by Compass (disturbed).	I. Deviation when Heeling 10° Port.	II. Change of Deviation from Heeling 10° Port.	III. Deviation. Ship Upright.	IV. Change of Deviation from Heeling 10° Starboard.	V. Deviation when Heeling 10° Starboard.
	° ′	° ′	° ′	° ′	° ′
North	+11 20	+18 30	− 7 10	−18 30	−25 40
N. by E.	+ 9 50	+18 9	− 8 19	−18 9	−26 28
N.N.E.	+ 7 45	+17 6	− 9 21	−17 6	−26 27
N.E. by N.	+ 4 57	+15 23	−10 26	−15 23	−25 49
N.E.	+ 1 20	+13 5	−11 45	−13 5	−24 50
N.E. by E.	− 3 2	+10 17	−13 19	−10 17	−23 36
E.N.E.	− 7 59	+ 7 5	−15 4	− 7 5	−22 9
E. by N.	−13 12	+ 3 37	−16 49	− 3 37	−20 26
East	−18 20	0 0	−18 20	0 0	−18 20
E. by S.	−22 56	− 3 37	−19 19	+ 3 37	−15 42
E.S.E.	−26 35	− 7 5	−19 30	+ 7 5	−12 25
S.E. by E.	−28 52	−10 17	−18 35	+10 17	− 8 18
S.E.	−29 34	−13 5	−16 29	+13 5	− 3 24
S.E. by S.	−28 31	−15 23	−13 8	+15 23	+ 2 15
S.S.E.	−25 49	−17 6	− 8 43	+17 6	+ 8 23
S. by E.	−21 38	−18 9	− 3 29	+18 9	+14 40
South	−16 20	−18 30	+ 2 10	+18 30	+20 40
S. by W.	−10 21	−18 9	+ 7 48	+18 9	+25 57
S.S.W.	− 3 9	−17 6	+13 57	+17 6	+31 3
S.W. by S.	+ 3 45	−15 23	+19 8	+15 23	+34 31
S.W.	+ 8 0	−13 5	+21 5	+13 5	+34 10
S.W. by W.	+11 16	−10 17	+21 33	+10 17	+31 50
W.S.W.	+14 23	− 7 5	+21 28	+ 7 5	+28 33
W. by S.	+16 22	− 3 37	+19 59	+ 3 37	+23 36
West.	+17 20	0 0	+17 20	0 0	+17 20
W. by N.	+17 26	+ 3 37	+13 49	− 3 37	+10 12
W.N.W.	+17 59	+ 7 5	+10 54	− 7 5	+ 3 49
N.W. by W.	+18 10	+10 17	+ 7 53	−10 17	− 2 24
N.W.	+17 14	+13 5	+ 4 9	−13 5	− 8 56
N.W. by N.	+15 17	+15 23	− 0 6	−15 23	−15 29
N. N.W.	+13 25	+17 6	− 2 41	−17 6	−20 47
N. by W.	+13 28	+18 9	− 4 41	−18 9	22 50

75. Having the change of deviation for 10° heel tabulated we can readily calculate the change for any other amount of heel, by multiplying the given change for 10° heel by the number of observed degrees of heel and removing the decimal point one figure to the left. Thus we find by the table above that with a S.W. course the change of deviation produced by heeling ten degrees to port is, $-13° 5' = -13°.1$. If we require to know the change of deviation with ship's head in the same direction but heeling thirteen degrees $-13°.1 \times 13 = -170°.3$, re-

moving the decimal one figure to the left, we have $-17°.03 = -17° 2'$, which added algebraically (52) to the deviation when the ship was upright, which the table shows to be $+21° 5'$, gives $+4° 3'$ ($+21° 5'$ added to $-17° 2' = +4° 3'$) which is the deviation when heeling thirteen degrees to port with the ship's head S.W. by compass. (Compensation for heeling. See Appendix D.)

The Necessity for checking the Compass by frequent Azimuths.

76. It is presumed that few if any captains of iron ships will place implicit reliance on their compasses, and it is therefore very desirable that every facility should be afforded them for determining by the bearings of heavenly bodies the deviations of their compasses. In order to accomplish this object it is absolutely necessary that he should be enabled to ascertain the variation of the compass at any part of the oceans and navigable seas.

77. Mr. F. J. O. Evans, R.N., has rendered invaluable services both to the Royal Navy and Mercantile Marine, by the construction of his variation charts. With an amount of labour highly creditable he has from various sources collected facts which have enabled the Admiralty to publish the most reliable variation chart in existence. No doubt, Mr. Evans was much assisted by the investigations of General Sabine, M. Gauss, and Professor Adolphe Erman, but the investigations of these philosophers have been reduced by Mr. Evans to a most practical form.

78. The chart is a general Mercator's chart of the world, with lines of equal variation differing one degree, made up to the epoch of 1858, appended to which is a chartlet showing the annual change at each point, where the change is greater or less than in neighbouring localities. In the chart + signifies east, and − west. In the chartlet the signs are not to be regarded algebraically, but plus (+) signifies that the variation, of whatever name (+ or −) is increasing annually to the amount of the given number of minutes, or minus (−) that it is decreasing. Every iron ship should be provided with this chart, without which the most careful observations would not enable the captain to determine how much of the error of the compass is due to deviation and how much to variation.

79. Next, the navigator of an iron ship should be enabled to determine the error of his compass by azimuths of any heavenly body in a favourable position. The comparison of the true azimuth with the bearing by compass gives the combined effects of variation and deviation, which is the "*correction*" to be applied to courses steered on the same line of equal variation, with the ship's head in the same direction as when the azimuth was taken, and the variation chart enables the mariner to separate the two. He should also be provided with a clinometer or instrument to show the number of degrees of the ship's heel. This instrument may be a very simple one, the only important part of its construction being a correctly divided and

centred arc. The index should be weighted so as to be at all times vertical, and thus showing on the arc the amount of the ship's heel; it should be fixed in the centre of some athwartship bulkhead, in a place convenient for inspection. For the want of this simple instrument several sets of careful and otherwise well arranged observations of deviations at sea have been of less value than they might have been on account of the heel of the ship not being recorded.*

80. The best method of determining the difference between the true and compass bearings is by time azimuths;† it requires but one observer, and is always available, whether the ship is in port, or at sea when the altitude cannot be observed on account of the horizon not being visible. The only objection to time azimuths has been the difficulty attendant on their calculation, and several contrivances have been adopted to reduce this labour. The following tables will, it is presumed, do away with this objection, since the time necessary to calculate the time azimuths of any heavenly body is less than that which is required to work an amplitude. These azimuths, since they only require a few minutes to determine, should be frequently taken whenever the state of the atmosphere will allow. In fine weather, whenever the heel of the ship changes or the direction of her head is changed, either night or day, an azimuth should be taken. Night azimuths are not generally observed, except that of the North Star, the bearing of which is frequently taken when its altitude is so great as to render the observation liable to great instrumental errors; this practice should therefore be discouraged. The smaller the altitude the greater the reliance that may be placed on the observed azimuths. When an opportunity presents of taking azimuth of several stars, the lowest that can be observed should be preferred, although it seldom happens that a star can be observed at less than 10° altitude, yet the altitude ought not to exceed 30°. An azimuth of a star can seldom be observed by reflexion, consequently with ordinary azimuth compasses the star should not be higher than the vane. The slit of the sight vane must be the twentieth of an inch wide, otherwise so much of the star's light is shut off from the eye as to render a star invisible.

To determine the Sun's True Azimuth by the Tables.

81. On board of every iron ship a watch should be kept to apparent time at ship, and as the longitude of the ship changes, should, at least once a day, be set right either by making it agree with the apparent time found in the calculation of mean time for determining longitude with chronometer, or from the Greenwich time by chronometer reduced if minus (−), or augmented if plus (+), as the case may require, by equation of

* A very superior clinometer invented by Commander A. G. Edye, R.N., is used in Her Majesty's Navy, which both shows the heel of the ship and registers the oscillations when the ship is rolling.

† Very valuable tables, giving time azimuths of the sun by inspection, for the latitudes 49 and 50, have been computed by John Burdwood, Master R.N., of the Hydrographic Office. These are intended to aid the mariner on his approach to the Channel, and an extension of these tables is contemplated.

time (taken from the right-hand page of the Nautical Almanac by longitude in time, and by error of chronometer, thus :—

1856, February 24th, chronometer shows $11^h.\ 8^m.$ was slow January 29th $0^h.\ 48^m.\ 20^s$, losing daily $7^s{\cdot}5$. Longitude 108° 40′ E. Required apparent time at ship.

		h	m	s	° ′
Time by chronometer . .	+	11	8	0	7·5
East long. in time . .	+	7	14	40	26
Chronometer slow . .	+	0	48	20	—
Accumulated rate losing .	+	0	3	15	45
					15
		19	14	15	
Equation of time . .	−	0	13	26	60)19·5
		19	0	49	3·15
		12	0	0	
Apparent time by watch .		7	0	49	

82. Take out the approximate declination from Table I., and with this at the head of Table III., and with the time shown by watch either in the right or left side columns take out the corresponding Arc I., and Log I., and under Arc I. write down the ship's latitude.

83. If the latitude and declination be of the same name, and the time from noon is less than six hours, Arc II. will be the difference between the latitude and Arc I. (Fig. I.*.)

84. If the time from the meridian passage be greater than six hours Arc II. will be the sum of the latitude and Arc I. If, however, this sum is greater than 90° it must be subtracted from 180°, and this supplement will be Arc II. (Fig. III.*)

85. In all cases when the latitude and declination are of contrary names, Arc II. is the sum of latitude and Arc I. (Fig. IV.*)

86. With Arc II. enter Table VIII., and take out Log. II. for the nearest 10 minutes of arc, which added to Log. I. will give the log. of azimuth, and the corresponding true azimuth to the nearest 10 minutes is given in Table IX.

87. If Arc II. be less than 10′ the right angle is very near the zenith (Fig. V.*), and the heavenly body for practical purposes may be regarded as being on the prime vertical ; then if it be the sun the true bearing will be east or west according whether the time is a.m. or p.m., or if any other heavenly body whether the hour angle is east or west (95).

88. If Arc I. be greater than the latitude, mark the azimuth north or south, according to whether the latitude is north or south. (Fig. II.*)

89. If the time from noon be greater than six hours, mark the azimuth with the same name as the latitude. (Fig. III.)

90. If Arc I. be less than the latitude, and the time from noon less than six hours, the azimuth will be of contrary name to the latitude. (Fig. I.*)

91. If the latitude and declination be of contrary names in all cases, the azimuth will be of the same name as the declination. (Fig. IV.*)

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* *The Figures above referred to are the figures in Appendix A.*

92. In all cases the true azimuth taken before apparent noon must be marked E, but in the afternoon W.

To find the Azimuth of the Moon.

93. Find the Greenwich time either by chronometer or by ship's mean time, and longitude in time, and take out of the Nautical Almanac (page for month V. to XII.), the Moon's R.A. and Dec. for the nearest hour of Greenwich date.

94. From Table V. take out the Sun's R.A. for the day, and from Table VI. the correction for longitude, and apparent time, and under these place the apparent time by watch* ; these three added together will give sidereal time at ship.

95. From the sidereal time take the Moon's R.A., and the remainder will be the Moon's hour angle west, but should the Moon's R.A. be greater than the sidereal time, 24 hours must be added to the latter, but if the hour angle west is greater than 12 hours, take it from 24 hours, and the remainder will be the hour angle east, unless it is greater than 24 hours, in which case it must be diminished by 24 hours, and the hour angle will be west.

96. Enter Table III. with the hour angle either east or west, as the case may be, instead of apparent time, in the case of the Sun (81), except that if the hour angle be 0 hours, the side column must be entered with 12 hours—thus, in Example 7 (112) for hour angle $0^h\ 52^m$ we must enter table with apparent time $12^h\ 52^m$.

97. Take out arc I. and log. I., and determine the value of log. II. in the manner described in calculating azimuths of the Sun, and in like manner (83, 84, and 85) the sum of log. I. and II. will be the log. of the azimuth required.

98. To determine whether the Moon will bear north or south, the same rules must be adopted as with the Sun's true azimuth (87 to 91).

99. If Table III. be entered with hour angle west (95) the bearing of the Moon must be marked W., but if with hour angle east (95) it must be marked E.

To find the Azimuth of a Planet.

100. To determine the azimuth of a planet the same rules are to be adopted as in determining the azimuth of the moon (94 to 99,) but in this case it is unnecessary to find the Greenwich date, the R.A. and dec. given for the planet for the day, being sufficiently approximate for the purpose.

To find the True Azimuth of a Star.

101. Find the sidereal time (94) and enter Table VII., and take out the star's R.A. at the head of the column immediately below the name of the star, and with this find the star's hour angle west, or hour angle east (95), as the case may be.

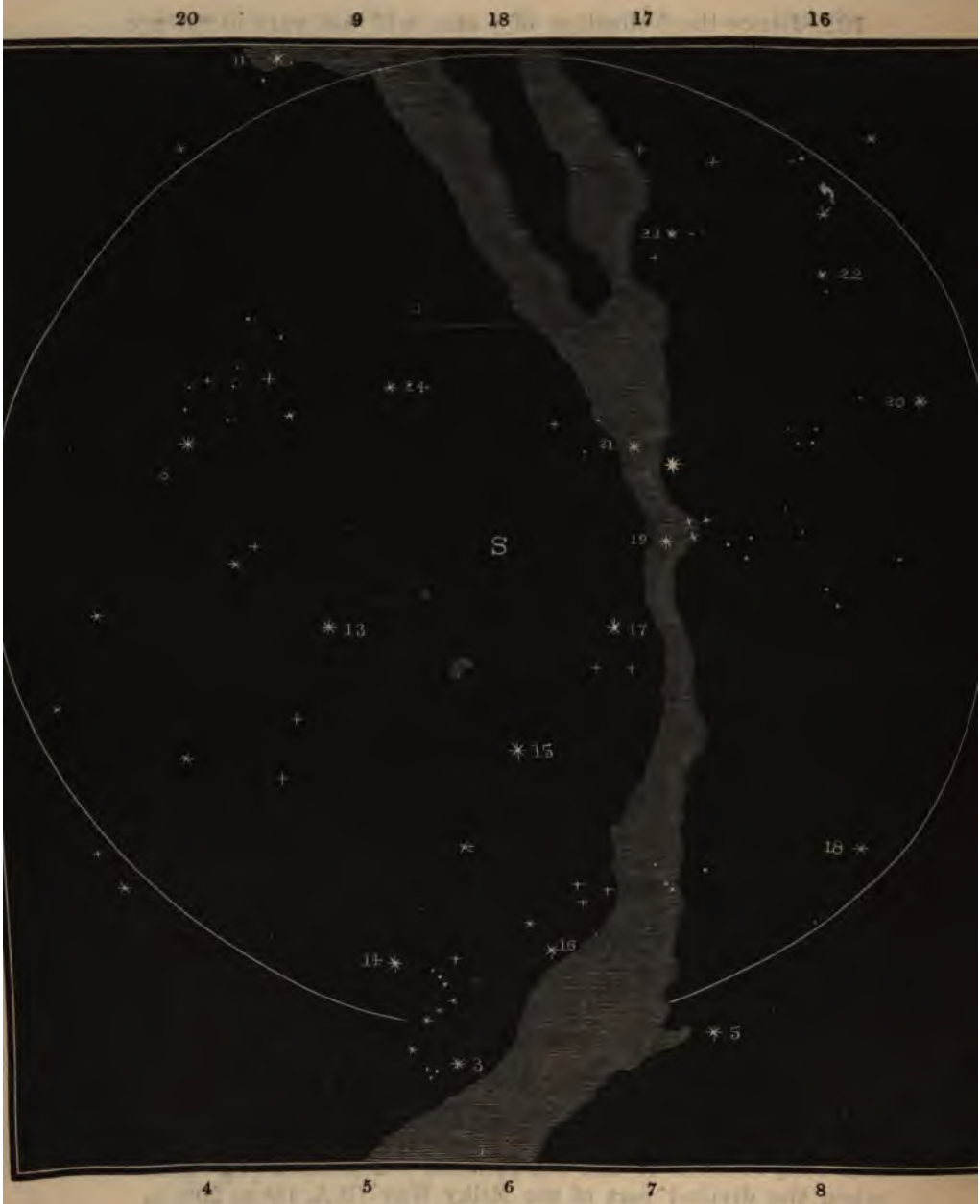
* Should the apparent time be after midnight and before 1^h a.m., 0^h should be here used and not 12^h, as in the previous cases in which Table III. has been referred to.

102. Since the declination of a star will not vary in an age to such an extent as to affect the true azimuth, the arc I. and log. I. is taken out of the table against the hour angle, which is ascertained as in the case of the moon (94) but the R.A. being given under the name of the star in Table VII. renders it unnecessary, as in the case of the moon or planet, to refer to the Nautical Almanac. In all other respects the azimuth is determined by the same rules as in the case of the moon.

103. When an azimuth of a star is to be observed, determine the sidereal time (94), and enter Table IV. with the nearest 10° of latitude in the side, and the sidereal time at the top, and the number of the star given in Table VII. that will be well situated for an azimuth being observed will be found; if the bearing be east of the meridian above the line, if west below it, and since the star thus given is never more than 30° or less than 10° above the horizon, under ordinary circumstances, little liability of mistake can exist; but to assist the observer two maps are appended, one having the position of the principal stars in the northern hemisphere given, page 44, and the other, containing the stars of the southern hemisphere, page 46. In both, the stars whose arc I. and log. I. are given in Table VII., are numbered in the same manner as in Tables IV. and VII. In both, maps that bright band in the heavens, generally called the Milky Way, is given, which in many cases will suffice to direct the observer to the star the azimuth of which is to be observed.

104. If any doubts remain, and the star has north declination, take the above map of stars in the northern hemisphere, and direct the sidereal time (94), given in the margin, towards the south, and with the face of the map towards the eye, and slanting it towards the horizon, compare the stars given in the map and those by which it is surrounded, with the stars in that part of the heavens towards which you are holding the map, keeping in mind that the altitude of the star sought is not more than 30°. The eye may also be guided towards any star named below, by its relative position to the Milky Way. Thus Capella [2] and Procyon [5] are nearer the eastern verge, Capella being the northernmost, and Castor [4] and Pollux further to the east, Castor being to the northward of Pollux. On the side of the Milky Way, opposite to Procyon, is α Orionis [3], being the nearest to the Milky Way of any star of considerable magnitude in this most remarkable constellation. To the north-west of this star, between it and the Pleiades, is Aldebaran [1]. Also when the divided part of the Milky Way (R.A. 18^h to 20^h) is above the horizon, Altair [11] may be distinguished by being immersed in the eastern division, and Vega [10] not far to the N.W. on the western or opposite side.

105. When the star to be observed has south declination, the map of stars in the southern hemisphere must be employed as required in the last section, with the exception that the hour of sidereal time in the margin of this map must be directed towards the north instead of south. The Milky Way is equally



The stars above are thus numbered in the map and in Tables IV. and VII., and are named as in the Nautical Almanac, except that the place of β Argûs is not there given.

13. α Eridani (Achernar).
14. β Orionis (Rigel).
15. α Argûs (Canopus).
16. α Canis Majoris (Sirius).
17. β Argûs.
18. α Hydræ.
19. α Crucis.
20. α Virginis (Spica).
21. α Centauri.
22. α Libræ.
23. α *Scorpii* (Antares).
24. α Pavonis.

useful in directing the eye to the star to be there observed as it is in the northern hemisphere; thus Sirius [16] is about 10° to the west of the Milky Way and 15° to the east of β Orionis [14]. In the southern hemisphere we have besides the Milky Way two remarkable objects to aid us in distinguishing the star we wish to observe. These consist of two nebulous patches, generally known by the names of the greater and lesser Magellanic clouds. The lesser is the nearer to the south pole, being about midway between the Pole and Achernar [13]. A line from Achernar produced midway between the greater and lesser cloud passes through β Argûs [17], which is also about 7° to the southward of the Milky Way, that is, on the same side as the Magellanic clouds.

A straight line produced from the lesser through the greater cloud passes nearly through Canopus [15], which star is on the same side of the Milky Way. A line from Canopus [15] through β Argûs and produced through the Milky Way, passes α Crucis, the brightest star of the very remarkable constellation of the Cross. This star, "the foot of the Cross," and all others of that constellation except the northernmost are within the Milky Way; between the Cross and the divided part of the Milky Way are the two brightest stars in the southern hemisphere, α Centauri and β Centauri, the former [21] within the Milky Way, the latter on the verge opposite to that on which β Argûs is situated. Further from the Pole, about 4° from the same side of the Milky Way is Antares [23]. With this guide each star named below although near the South Pole, might be distinguished by those by whom it has never before been seen.

Example 1.

106. 1865, February 20. $4^h\ 12^m$ p.m. apparent time at ship; Lat. 50° N., Long. 27° W.; the bearing of the sun by compass N. 57° W.; required the variation and deviation of the compass.

By Table I., approx. dec. S. 11°.	Table III., arc I.	° ′ 23 11	Log. I. 10·2562	
App. time at ship $4^h\ 12^m$.	Latitude	50 0 N.		
	Arc II., sum (85)	73 11	Log. II. ·0190	Table VIII.
	True Azimuth (91)	S. 62 W.	10·2752	Table IX.
		*180		
		N. 118 W.		
Sun's bearing by compass		N. 57 W.		
	Correction	61 W.		
Variation from Admiralty Variation Chart		35 W.		
	Deviation	26 W.		

* As in ordinary azimuths the true azimuth should be made north or south according as the magnetic is north or south.

Example 2.

107. 1865, May 7. $7^h\ 12^m$ p.m. apparent time at ship; Lat. 50 N., Long. 170° E.; the bearing of the sun by compass N. 60°. 30′ W.; required the variation and deviation of the compass.

		° ′	
Approx. dec. N. 17°. App. time at ship $7^h\ 12^m$	Arc I. Latitude	44 41 50 0 N.	Log. I. 10·3400
	Sum (84)	94 41 180	
	Arc II. (84)	85 19	Log. II. 0·0014
	True azimuth (89)	N. 65 30 W.	10·3414

Sun's bearing by Compass N. 60 30 W.

Correction	5 0 W.
Variation from Admiralty Variation Chart -	10 0 E.
Deviation	15 0 W.

Example 3.

108. 1865, August 24. $6^h\ 48^m$ a.m. apparent time at ship; Lat. 50° N., Long. 36° W.; the bearing of the sun by compass N. 84° E.; required the variation and deviation of the compass.

		° ′	
Approx. dec. 11° N. App. time at ship $6^h\ 48^m$ a.m.	Arc I. Latitude	43 5 50 0 N.	Log. I. 10·5362
	Arc II. diff. (83)	6 55	Log. II. ·9193
	True azimuth (90)	S. 88° E	11·4555

180

N. 92 E.

Sun's bearing by compass N. 84 E.

Correction	8 E.
Variation from Admiralty Variation Chart -	38 W.
Deviation	46 E.

Example 4.

109. 1865, June 20. $4^h\ 0^m$ p.m. apparent time at ship; Lat. 41° N., Long. 28° W.; the bearing of the sun by compass was

N. 43° W.; required the variation and deviation of the compass.

		° ′
Approx. dec. 23° 30′ N.	Arc I.	41 1
App. time at ship 4h 0m p.m.	Latitude	41 0
	Arc II.	0 1

Arc II. being less than 10′ the sun is near the prime vertical, and being p.m. it is west or N. 90° W. true
Compass bearing N. 43 W.

Correction 47 W.
Variation 28 W.

Deviation 19 W.

Had the compass bearing been S. 43° W. we should have called the true S. 90° W.

Example 5.

110. 1865, July 15. 7h 24m a.m. apparent time at ship; Lat. 34° N., Long. 157° E.; the bearing of the sun by compass was N. 61° E.; required the variation and deviation of the compass.

		° ′		
Approx. dec. 21° 30′.	Arc I.	47 41	Log. I.	10·2439
App. time at ship 7h 24m a.m.	Latitude	34 0		
	Arc II. the diff. (83)	13 41	Log. II.	·6266
	(88) True Azimuth N.	82 20 E.		10·8705
	Sun bearing by compass N.	61 0 E.		

Correction 21 20 E.
Variation 5 0 E.

Deviation 16 20 E.

Example 6.

111. 1865, July 8. 4h 1m a.m. apparent time at ship; Lat. 32° N., Long. 151° E.; the bearing of the moon by compass was S. 48° W.; required the variation and deviation of the compass.

	h	m			h	m
July 7th	16	1	a.m.	Table 5 Sun's approx. R.A., July 8th	7	6
Long. in time	10	4	E.	Table 6 correction for 4 a.m. and Long. 150° E.	12	1
G. M. T.	5	57		☽'s R.A. 18h 7m; Dec. 19° S. Appt. time at ship	4	1
				Sidereal time	23	8
				☽'s right ascension	18	7
				☽'s hour angle W.	5	1

Table III. column appt. time 5^h; dec. 19° N.	Arc I.	53° 1′ N.	Log. I.	10·3506
	Latitude	32 0 S.		
Sum (85)	Arc II.	= 85 1	Log. II.	·0017
☽'s true azimuth (91)		S. 66° W.		10·3523
☽'s bearing by compass		S. 48 W.		
	Correction	18 E.		
	Variation	2 E.		
	Deviation	16 E.		

Example 7.

112. 1865, June 9. $11^h\ 40^m$ p.m. apparent time at ship; Lat. 53° N., Long. 13° West; the bearing of the moon by compass was S. 15° 10′ W.; required the variation and deviation of the compass.

	h	m			
June 9 - -	11	40	p.m.		
Long. in time -		52			
G. M. T. -	12	32	☽'s R.A.	$17^h\ 45^m$	; dec. 19° S.

	h	m
Sun's approximate R.A. - - -	5	6
Corr. for $11^h\ 40^m$ p.m. Long. 13° W. -		7
Appt. time at ship - - -	11	40

	h	m		h	m
Sidereal time (95)	16	53	+24h =	40	53
☽ R.A.				17	45
☽ hour angle W.				23	8
				24	0
☽ hour angle E.				0	52

Approx. Dec. 19° S. Hour angle $0^h\ 52^m$	Arc I. -	19° 28′	Log. I. -	9·3378
	Latitude	53 0 N.		
Arc II. sum (85)		72 28	Log. II. -	0·0206
				9·3584
☽'s true azimuth		S. 12° 50′ E.		
☽'s bearing by compass		S. 15 10 W.		
	Correction	28 0 W.		
	Variation	38 0 W.		
	Deviation	10 0 E.		

Because the hour angle is less than 1 hour, Table III. must be *entered on* the right side column under apparent time with *$12^h\ 52^m$ instead* of $0^h\ 52^m$ (96).

Example 8.

113. 1865, February 2. $8^h\ 12^m$ p.m. apparent time at ship; Lat. 52° 30′ N., Long. 5° 30′ West; Venus bore by compass S. 89° 10′ W.; required the variation and deviation of the compass.

February 2, R.A. $23^h\ 56^m$.
Dec. 0° 30′ S.; Hour angle $5^h\ 21^m$

				h	m
Arc I.	2 53	Log. I.	10·7531	Sun's approximate R.A.	20 59
Lat.	52 30			$8^h\ 12^m$ p.m. Long. 5° 30′ W.	6
				Apparent time - -	8 12
Arc II.	55 23		·0849	Sidereal time - -	29 17
				R. A. of Venus - -	23 56
		Log. II.	10·8380		
				Hour angle W. - -	5 21

		°	′	
		S. 81	40	W.
		S. 89	10	W.
Correction	-	7	30	W.
Variation	-	25	0	W.
Deviation	-	17	30	E.

Example 9.

114. 1865, June 25. $3^h\ 18^m$ a.m. apparent time at ship; Lat. 31° N., Long. 31° W.; Jupiter bore by compass N. 84° W.; required the variation and deviation of the compass.

June 25th, R.A. $17^h\ 29^m$; dec. 23° S.; hour angle $4^h\ 6^m$.

Hour angle $4^h\ 4^m$. Dec. 23° S.

		°	′		
Arc I.	-	41	13	Log. I.	10·1326
Lat.	-	31	0	N.	
Arc II.	-	72	13	Log. II.	·0214
					10·1540

	°	′	
S.	55	0	W.
	180	0	
N.	125	0	W.
N.	84	0	W.
Correction	41	0	W.
Variation	21	40	W.
Deviation	19	20	W.

	h	m
Sun's approximate R.A.	6	12
$3^h\ 20^m$ a.m., long. 31° W.	12	3
Apparent time - -	3	18
Sidereal time - -	21	33
R.A. of Jupiter - -	17	29
Hour angle West - -	4	4

Example 10.

115. 1865, June 25. $9^h\ 27^m$ p.m. apparent time at ship; Lat. 30° N., Long. 31° W.; Mars bore by compass N. 54° 15′ W.; required the variation and deviation of the compass.

June 25th. R.A. $9^h\ 27^m$; dec. 16° 20′ N.; hour angle $6^h\ 18^m$ W.

Hour angle $6^h\ 18^m$ / Dec. 16° 30′ N.	Arc I.	73° 34′	Log. I.	10·5086	
	Lat.	30 0			
		103 34			
		180 0			
	Arc II.	76 26	Log. II.	·0122	
				10·5208	N. 73° 15′ W.
					N. 54 15 W.
		h m			
Sun's approximate R.A.		6 12			
$9^h\ 27^m$ p.m., long. 31° W.		0 6		Correction	19 0 W.
Apparent time at ship		9 27		Variation	21 0 W.
Sidereal time		15 45			
R.A. of Mars		9 27		Deviation	3 0 E.
Hour angle, West		6 18			

Example 11.

116. 1865, July 11. $7^h\ 45^m$ p.m. apparent time at ship; Lat. 5° 30′ N., Long. 30° 10′ W.; α Crucis bore by compass S. 44° 10′ W.; required the variation and deviation of the compass.

Hour angle $2^h\ 50^m$.					
	Arc I.	69° 0′	Log. I.	9·5232	
	Lat.	5 30			
	Arc II.	74 30	Log. II.	·0161	
				9·5393	
					Azimuth S. 19° 0′ W.
					Star by compass S. 44 10 W.
		h m			
Sun's approximate R.A.		7 18		Correction	25 10 W.
$7^h\ 45^m$ p.m., long. 30° 10′ W.		0 6		Variation	12 40 W.
Apparent time at ship		7 45			
				Deviation	12 30 W.
Sidereal time		15 9			
Star's R.A.		12 19			
Star's hour angle, West		2 50			

Example 12.

117. 1865, June 1. $2^h\ 24^m$ a.m. apparent time at ship; Lat. 56° 10′ N., Long. 8° 30′ W.; Arcturus bore by compass

N. 43° W.; required the variation and deviation of the compass.

Hour angle $4^h\ 50^m$.

Arc I. 51 7	Log. I. 10·3130				
Lat. 56 10					
				h	m
Arc II. 5 3	Log. II. 1·0597		Sun's App. R.A.	4	33
			$2^h\ 44^m$ a.m., long. 8° 30′ W.	12	3
11·3727	S. 87 40 W.		Apparent time	2	24
	180 0				
	N. 92 20 W.			19	0
	N. 43 0 W.		Star's R.A. -	14	10
	Correction 49 20 W.		*'s hour angle W.	4	50
	Variation 28 0 W.				
	Deviation 21 20 W.				

Example 13.

118. 1865, June 27. $9^h\ 15^m$ p.m. apparent time at ship; Lat. 27° N., Long. 30° 46′ W.; Polaris (the Polar Star) bore by compass N. 52° 19′ E.; required the variation and deviation of the compass.

Lat. 27° N., Sidereal time, $15^h\ 42^m$.

				h	m
By Table II. Polaris bears	N. 1 9 E.		Sun's App. R.A. -	6	21
	N. 52 19 E.		$9^h\ 15^m$ p.m., long. 30° W.	0	6
			Apparent time - -	9	15
	Correction 51 10 W.				
	Variation 19 30 W.		Sidereal time - -	15	42
	Deviation 31 40 W.				

119. When an iron ship is lying in a harbour or other anchorage, it is desirable that the correct magnetic bearing of some distant object should be determined. This may be readily done by observing, on a moonlight night, when the moon, or a planet, or either of the stars given in Table VII. is in the vertical line above such distant object, or during the daytime, when the sun or moon is so situated.

EXAMPLE 1.—July 22, 1865; apparent time at ship $1^h\ 57^m$ a.m., lying at anchor in Plymouth Sound; Lat. 50° 20′ N., Long. 4° 7′ W.; α Ursæ Majoris was observed on the vertical line above Brent Tor; required the true and correct magnetic bearing of Brent Tor from the ship.

	h	m			
Appt. time	1	57	Arc I. 63 5	Log. I.	9·0191
Sun's appx. R.A.	8	3	Lat. 50 20		
From Table IV.	12	3	113 25		
	22	3	180		
*'s R.A.	10	55	66 35		0·0376
*'s hour angle W.	11	8	True bearing	N. 6 30 W.	9·0567
			Variation West	23 30	
			Correct magnetic	N. 17 0 E.	

120. Observations made at Sea should

Year.	Day of the Month.	Apparent Time.	Latitude.	Longitude.	Ship's Head by Standard Compass.	Heel by Clinometer.	Body observed.
		H. M.	d. m.	d. m.			
1865	June 1	2 24 a.m.	56 10 N.	8 30 W.	S.E. ¼ E.	2 S.	Arcturus.
	2	10 12 p.m.	56 6 N.	10 10 W.	S.E. ½ E.	2 S.	α Lyræ.
	3	10 10 p.m.	55 45 N.	11 50 W.	S.E. by E.	3 S.	α Virginis.
	3	6 30 p.m.	55 26 N.	13 40 W.	S.E. by E.	0	Sun.
	4	6 10 a.m.	55 10 N.	16 20 W.	S.E. by E.	10 P.	Sun.
	4	11 50 p.m.	55 2 N.	18 0 W.	S.S.E.	5 P.	Altair.
	6	7 14 a.m.	54 45 N.	21 42 W.	S.S.E.	0	Sun.
	7	2 8 a.m.	54 25 N.	22 25 W.	S.	0	Arcturus.
	8	6 11 a.m.	54 5 N.	23 50 W.	S.	5 S.	Sun.
	8	5 45 p.m.	53 42 N.	26 10 W.	S.E.	0	Sun.
	8	11 56 p.m.	53 20 N.	26 50 W.	S.W.	0	Antares.
	9	11 40 p.m.	53 0 N.	28 0 W.	W. by S.	4 S.	Moon.
	10	2 18 a.m.	52 22 N.	29 36 W.	S.E. by E.	5 S.	Arcturus.
	11	7 15 p.m.	51 43 N.	31 12 W.	S.E. by E.	0	Sun.
	12	10 0 p.m.	51 1 N.	32 48 W.	S.E. by E.	10 S.	Capella.
	13	9 12 p.m.	50 40 N.	34 24 W.	East.	0	Jupiter.
	14	6 48 a.m.	50 0 N.	36 0 W.	S. by W.	8 P.	Sun.
	15	2 52 a.m.	48 10 N.	34 42 W.	S.E.	5 S.	Venus.
	16	6 12 p.m.	46 20 N.	33 19 W.	S.E.	5 P.	Sun.
	17	5 15 a.m.	45 48 N.	32 7 W.	S.E.	0	α Ursæ Maj.
	18	6 12 a.m.	44 0 N.	30 37 W.	S.S.W.	0	Sun.
	19	3 10 a.m.	42 30 N.	29 18 W.	S.S.W.	10 S.	Venus.
	20	4 0 p.m.	41 0 N.	28 0 W.	S.S.W.	10 P.	Sun.
	22	3 30 a.m.	37 3 N.	29 6 W.	E. by N.	5 S.	Venus.
	23	9 30 p.m.	35 5 N.	30 2 W.	E. by N.	8 P.	Mars.
	25	2 48 a.m.	31 0 N.	31 0 W.	E. by N.	0	Venus.
	25	3 18 a.m.	31 0 N.	31 0 W.	S. 40° W.	10 P.	Jupiter.
	25	9 27 p.m.	30 0 N.	31 0 W.	S. 18° W.	10 S.	Mars.
	26	5 34 a.m.	28 30 N.	30 50 W.	S.S.E.	5 S.	Sun.
	27	12 36 a.m.	27 0 N.	30 46 W.	S.S.E.	5 P.	Polaris.
	28	9 30 p.m.	25 30 N.	30 27 W.	S. 20° W.	10 P.	Moon.
	29	10 12 p.m.	24 10 N.	30 30 W.	S. 45° W.	0	Moon.
	30	10 55 p.m.	22 30 N.	30 28 W.	East.	8 P.	Moon.
	July 1	5 50 a.m.	21 0 N.	30 31 W.	E.S.E.	5 S.	Aldebaran.
	2	5 50 a.m.	19 10 N.	30 40 W.	S.E.	10 P.	Sun.
	3	5 10 a.m.	17 40 N.	30 35 W.	E. by S.	5 S.	Vega.
	4	1 50 a.m.	15 50 N.	30 27 W.	S.S.E.	9 P.	Moon.
	5	2 29 a.m.	14 0 N.	30 28 W.	S.W.	1 S.	Moon.
	6	3 11 a.m.	12 30 N.	30 27 W.	E.S.E.	11 S.	Moon.
	7	6 10 a.m.	11 0 N.	30 26 W.	S.E.	1 P.	Sun.
	8	5 50 p.m.	9 30 N.	30 24 W.	E.S.E.	5 S.	Sun.
	9	7 27 p.m.	8 10 N.	30 18 W.	E. by N.	5 S.	Moon.
	10	8 40 p.m.	6 50 N.	30 14 W.	S.S.W.	1 P.	Moon.
	11	7 45 p.m.	5 30 N.	30 10 W.	S. 12° W.	0	α Crucis.
	12	7 30 p.m.	4 10 N.	30 5 W.	S. 30° W.	0	α Centauri.

ecorded in the following Form.

Compass bearing.	True bearing.	Correction.	Variation.	Deviation.	Day of the Month.	Year.
d. m.	d. m.	d. m.	d. m.	d. m.		
43 0 W.	N. 92 20 W.	49 20 W.	28 0 W.	21 20 W.	June 1	1865
36 50 E.	S. 87 20 E.	50 30 W.	29 30 W.	21 0 W.	2	
75 5 W.	S. 26 20 W.	48 45 W.	29 45 W.	19 0 W.	3	
17 25 W.	N. 70 20 W.	52 55 W.	30 30 W.	22 25 W.	3	
39 20 E.	S.101 20 E.	63 0 W.	32 30 W.	30 30 W.	4	
36 10 E.	S. 56 10 E.	65 15 W.	34 0 W.	31 15 W.	4	
38 40 E.	S. 99 10 E.	60 30 W.	36 0 W.	24 30 W.	6	
35 30 W.	N. 90 0 W.	54 30 W.	36 30 W.	18 0 W.	7	
54 10 E.	S.101 40 E.	47 30 W.	37 30 W.	10 0 W.	8	
7 15 W.	N. 78 50 W.	61 35 W.	38 0 W.	23 35 W.	8	
5 40 W.	S. 10 0 W.	34 40 W.	38 0 W.	3 20 E.	8	
4 40 W.	S. 13 20 E.	28 0 W.	38 0 W.	10 0 E.	9	
9 30 W.	N. 85 10 W.	55 40 W.	38 0 W.	17 40 W.	10	
1 15 W.	N. 61 10 W.	59 55 W.	38 15 W.	21 40 W.	11	
53 50 E.	N. 17 40 W.	51 30 W.	37 45 W.	13 45 W.	12	
7 40 W.	S. 40 0 E.	48 40 W.	38 30 W.	10 10 W.	13	
0 0 E.	S. 97 0 E.	67 0 W.	38 9 W.	29 0 W.	14	
9 15 E.	S.103 20 E.	54 5 W.	35 30 W.	18 35 W.	15	
9 33 W.	N. 71 20 W.	61 47 W.	33 30 W.	28 17 W.	16	
7 45 E.	N. 1 40 E.	56 5 W.	32 30 W.	23 35 W.	17	
58 20 E.	S.105 10 E.	36 50 W.	30 20 W.	6 30 W.	18	
9 50 E.	S.100 10 E.	20 20 W.	29 0 W.	8 40 E.	19	
7 0 W.	N. 90 0 W.	53 0 W.	28 0 W.	25 0 W.	20	
5 30 E.	S.106 10 E.	30 40 W.	25 0 W.	5 40 W.	22	
5 13 W.	N. 74 10 W.	28 57 W.	24 15 W.	4 42 W.	23	
7 0 E.	S.104 0 E.	27 0 W.	21 40 W.	5 20 W.	25	
4 0 W.	N.125 0 W.	41 0 W.	21 40 W.	19 20 W.	25	
4 15 W.	N. 73 15 W.	19 0 W.	21 0 W.	3 0 E.	25	
7 40 E.	N. 66 20 E.	21 20 W.	20 20 W.	1 0 W.	26	
2 19 E.	N. 1 38 E.	50 41 W.	19 30 W.	31 11 W.	27	
7 50 W.	N. 93 20 W.	18 30 W.	19 0 W.	0 30 E.	28	
9 35 W.	S. 82 50 W.	3 15 E.	18 0 W.	21 15 E.	29	
4 30 W.	N.100 10 W.	35 40 W.	17 30 W.	18 10 W.	30	
3 28 E.	S. 95 50 E.	32 22 W.	16 45 W.	15 37 W.	July 1	
3 5 W.	N. 67 20 W.	44 15 W.	15 30 W.	28 45 W.	2	
1 25 W.	N. 54 0 W.	32 35 W.	15 15 W.	17 20 W.	3	
4 29 W.	N.105 10 W.	40 41 W.	14 45 W.	25 56 W.	4	
3 10 W.	S. 71 30 W.	8 20 E.	14 0 W.	22 20 E.	5	
4 50 W.	N.109 55 W.	25 5 W.	13 30 W.	11 35 W.	6	
9 56 E.	S.111 40 E.	31 44 W.	13 20 W.	18 24 W.	7	
1 20 W.	N. 68 0 W.	26 40 W.	13 20 W.	13 20 W.	8	
1 50 E.	S. 73 30 E.	31 40 W.	13 10 W.	18 30 W.	9	
7 11 E.	S. 76 50 E.	0 21 E.	13 0 W.	12 39 E.	10	
4 10 W.	S. 19 0 W.	25 10 W.	12 40 W.	12 30 W.	11	
1 50 W.	S. 3 50 W.	20 0 W.	12 40 W.	7 20 W.	12	

The following remarks in the third report from the Liverpool Compass Committee to the Board of Trade (1857-60) is recommended to the attention of masters :—

"Undoubtedly the best practical corrective for errors of the compass of all kinds is to be found in a competent and careful captain. How to make the captains and future officers of iron ships more competent in this special department of their very varied duties deserves the most careful attention. A fair knowledge of the elements of magnetism and mechanics may, it is thought, be reasonably be required in the commander of an iron ship. The practical mode of correcting the compass is so simple, and may be acquired in so short a space of time, that every officer in an iron ship might be expected to show practically that he can perform this operation.

"Only those who have made it a subject of inquiry can form a correct idea of how large a proportion of the complaints respecting the compasses of iron ships have reference to their sluggishness and want of directive power. Either by celestial observation or by the "inverse" method, the correct direction of the ship's head is usually very approximately ascertained. What is chiefly required is a steering compass, which in all latitudes and in all directions of the ship's head, shall have enough directive power for the wants of the man at the wheel. It is to produce this desirable result that the Committee have already recommended the introduction of a vertical compensating bar in the construction of iron ships, and they now recommend the officers of iron ships to master for themselves the mode of properly applying a compensating magnet whenever it may be required at sea.

"But not unfrequently the reported compass errors of iron ships arise from purely mechanical causes, which have no connexion with the ship's magnetism. They are sometimes due to cracked or holed agates, but more commonly to worn pivots, with needles which have never had or have lost their proper directive power. An opinion prevails with some compass makers, that the steel pivot for the card should not be hardened, and a compass maker of some note actually refuses to supply any but pivots of soft steel, except by special request. The objects sought are stated to be preservation of the agate cap and steadiness of the card. Lapidaries and gem engravers consider that the soft metal would have the opposite effect; and any steadiness in the card which is due to a blunted pivot must necessarily be at the expense of accuracy.

"The number of cases which have come before this Committee of deviation arising from blunted and worn pivots is such as to leave no doubt that this is a most prevalent source of error and bad steering. In one case, in a screw steamer in active employment, the pivot had not even been examined for about eight months; in another screw steamer the pivot had not been changed or sharpened for nearly 12 months; and in a third case the agate cup in which the pivot rested had been filled up with brickdust, for the purpose, it was stated, of steadying the card, so that when examined it was found that the vibration from the screw and the grinding of the brickdust had made a hole

completely through the agate. In the last instance the captain had rectified a supposed error of two points by placing the compensating magnet in a position very much nearer the compass card, —so near, in fact, as to produce an error of the same extent."

Masters and mates of iron ships should make themselves acquainted with the following subjects:—

The elementary theory of magnetism, especially the laws of permanent (or sub-permanent) magnetism (6, 7, 8, 13, and 14), and those of inductive magnetism; the magnetic condition of the ship, arising from the direction of her head whilst building, and the nature of changes occurring after the ship is launched.

They should be able to swing their ship, and understand the methods of compensating both polar and quadrantal deviation (46 to 49).

The compass having been compensated, they should be acquainted with the means for correcting, from time to time, the changes which take place in the remaining deviation (50 and Appendix D.)

They should be able to determine the deviation by observation (51 to 64).

By means of the deviation with ship's head on eight points they should be enabled to determine the value of the five principal coefficients A, B, C, D, and E. (51 to 57.)

The coefficients being thus determined, they should be enabled to determine the deviation when the ship's head is on any point of the compass (59 to 64).

Having a table of errors to correct a course steered, they should be enabled to shape a course by means of a modification of such table (65).

Having a table of deviation determined by swinging the ship, they should by means of observations made when the ship's head is on two adjoining cardinal points, be able to modify such table so as to be useful in entering a distant port or in coming up Channel when returning after a distant voyage (66).

They should be acquainted with the construction and use of the clinometer (79).

They should be acquainted with the changes in the deviation caused by the ship's heeling; and having the deviation table for the ship on an even beam, and the change of deviation by heeling with the ship's head on any one point (except east or west nearly), to construct an approximate deviation table for ship when heeling (74) 10° starboard and 10° port, or to compensate for heeling by means of a vertical magnet (Appendix D.)

To determine the correction of the compass (80 to 118) by a time azimuth of the sun, moon, planets, or stars.

To determine the variation of the compass by means of the Admiralty (Evans') variation chart or otherwise, and to separate deviation from variation.

To record observations in a form suitable for further correction of the compass, or for their guidance under similar circumstances (120).

TABLE I.—SUN'S APPROXIMATE MEAN DECLINATION.

Day of the Month.	January.	February.	March.	April.	May.	June.	Day of the Month.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	
1	S. 23 0	S. 17 0	S. 7 30	N. 4 30	N. 15 0	N. 22 0	1
2	23 0	17 0	7 0	5 0	15 30	22 0	2
3	23 0	16 30	6 30	5 30	15 30	22 30	3
4	22 30	16 30	6 30	6 0	16 0	22 30	4
5	22 30	16 0	6 0	6 0	16 30	22 30	5
6	22 30	16 0	5 30	6 30	16 30	22 30	6
7	22 30	15 30	5 0	7 0	17 0	23 0	7
8	22 30	15 0	5 0	7 30	17 0	23 0	8
9	22 0	15 0	4 30	8 0	17 30	23 0	9
10	22 0	14 30	4 0	8 0	17 30	23 0	10
11	22 0	14 0	3 30	8 30	18 0	23 0	11
12	21 30	14 0	3 0	8 30	18 0	23 0	12
13	21 30	13 30	3 0	9 0	18 30	23 0	13
14	21 30	13 0	2 30	9 30	18 30	23 30	14
15	21 0	13 0	2 0	10 0	19 0	23 30	15
16	21 0	12 30	1 30	10 0	19 0	23 30	16
17	21 0	12 0	1 0	10 30	19 30	23 30	17
18	20 30	11 30	1 0	11 0	19 30	23 30	18
19	20 30	11 30	0 30	11 0	20 0	23 30	19
20	20 0	11 0	North.	11 30	20 0	23 30	20
21	20 0	10 30	N. 0 30	12 0	20 0	23 30	21
22	19 30	10 0	1 0	12 0	20 30	23 30	22
23	19 30	10 0	1 0	12 30	20 30	23 30	23
24	19 0	9 30	1 30	13 0	21 0	23 30	24
25	19 0	9 0	2 0	13 0	21 0	23 30	25
26	18 30	8 30	2 30	13 30	21 0	23 30	26
27	18 30	8 30	2 30	14 0	21 30	23 30	27
28	18 0	8 0	3 0	14 0	21 30	23 30	28
29	18 0	7 30	3 30	14 30	21 30	23 0	29
30	17 30	—	4 0	15 0	22 0	23 0	30
31	17 30	—	4 30	—	22 0	—	31

TABLE II.—BEARING OF POLARIS FOR EACH HOUR OF SIDEREAL TIME.

West Sidereal Time.	Latitude North.					East Sidereal Time.
	5°	20°	30°	40°	50°	
H. M.						H. M.
1 40	N. 0 11	N. 0 12	N. 0 13	N. 0 14	N. 0 18	0 40
2 10	N. 0 22	N. 0 24	N. 0 26	N. 0 29	N. 0 35	0 10
2 40	N. 0 33	N. 0 35	N. 0 38	N. 0 43	N. 0 53	23 40
3 10	N. 0 43	N. 0 46	N. 0 50	N. 0 56	N. 1 8	23 10
3 40	N. 0 52	N. 0 55	N. 1 0	N. 1 9	N. 1 22	22 40
4 10	N. 1 0	N. 1 5	N. 1 10	N. 1 20	N. 1 35	22 10
4 40	N. 1 8	N. 1 12	N. 1 19	N. 1 29	N. 1 47	21 40
5 10	N. 1 14	N. 1 19	N. 1 26	N. 1 37	N. 1 57	21 10
5 40	N. 1 19	N. 1 24	N. 1 31	N. 1 43	N. 2 4	20 0
6 10	N. 1 23	N. 1 28	N. 1 35	N. 1 48	N. 2 9	20 0
6 40	N. 1 25	N. 1 30	N. 1 38	N. 1 50	N. 2 12	19 40
7 10	N. 1 25	N. 1 30	N. 1 38	N. 1 51	N. 2 12	19 10

TABLE I.—SUN'S APPROXIMATE MEAN DECLINATION.

Day of the Month.	July.	August.	September.	October.	November.	December.	Day of the Month.
	d. m.	d. m.	d. m.	d. m.	d. m.	d. m.	
1	N. 23 0	N. 18 0	N. 8 0	S. 3 0	S. 14 30	S. 22 0	1
2	23 0	18 0	8 0	3 30	15 0	22 0	2
3	23 0	17 30	7 30	4 0	15 0	22 0	3
4	23 0	17 0	7 0	4 30	15 30	22 30	4
5	23 0	17 0	7 0	5 0	15 30	22 30	5
6	22 30	16 30	6 30	5 0	16 0	22 30	6
7	22 30	16 30	6 0	5 30	16 30	22 30	7
8	22 30	16 0	5 30	6 0	16 30	23 0	8
9	22 30	16 0	5 30	6 30	17 0	23 0	9
10	22 0	15 30	5 0	6 30	17 0	23 0	10
11	22 0	15 30	4 30	7 0	17 30	23 0	11
12	22 0	15 0	4 0	7 30	17 30	23 0	12
13	22 0	14 30	3 30	8 0	18 0	23 0	13
14	21 30	14 30	3 30	8 0	18 30	23 0	14
15	21 30	14 0	3 0	8 30	18 30	23 30	15
16	21 30	13 30	2 30	9 0	19 0	23 30	16
17	21 0	13 30	2 0	9 30	19 0	23 30	17
18	21 0	13 0	2 0	9 30	19 30	23 30	18
19	21 0	13 0	1 30	10 0	19 30	23 30	19
20	20 30	12 30	1 0	10 30	19 30	23 30	20
21	20 30	12 0	0 30	11 0	20 0	23 30	21
22	20 30	12 0	South.	11 0	20 0	23 30	22
23	20 0	11 30	0 0	11 30	20 30	23 30	23
24	20 0	11 0	S. 0 30	12 0	20 30	23 30	24
25	19 30	10 30	1 0	12 0	21 0	23 30	25
26	19 30	10 30	1 30	12 30	21 0	23 30	26
27	19 0	10 0	1 30	13 0	21 0	23 30	27
28	19 0	9 30	2 0	13 0	21 30	23 30	28
29	18 30	9 30	2 30	13 30	21 30	23 0	29
30	18 30	9 0	3 0	14 0	21 30	23 0	30
31	18 0	8 30	—	14 0	—	23 0	31

TABLE II.—BEARING OF POLARIS FOR EACH HOUR OF SIDEREAL TIME.

West Sidereal Time.	Latitude North.					East Sidereal Time.
	5°	20°	30°	40°	50°	
H. M.						H. M.
12 40	N. 0 11	N. 0 12	N. 0 13	N. 0 14	N. 0 17	13 10
12 10	N. 0 22	N. 0 23	N. 0 25	N. 0 28	N. 0 33	13 40
11 40	N. 0 33	N. 0 34	N. 0 37	N. 0 42	N. 0 49	14 10
11 10	N. 0 43	N. 0 45	N. 0 48	N. 0 54	N. 1 1	14 40
10 40	N. 0 52	N. 0 55	N. 0 59	N. 1 7	N. 1 19	15 10
10 10	N. 1 0	N. 1 4	N. 1 9	N. 1 17	N. 1 32	15 40
9 40	N. 1 8	N. 1 11	N. 1 17	N. 1 27	N. 1 43	16 10
9 10	N. 1 14	N. 1 18	N. 1 24	N. 1 35	N. 1 53	16 40
8 40	N. 1 19	N. 1 23	N. 1 30	N. 1 41	N. 2 1	17 10
8 10	N. 1 23	N. 1 27	N. 1 34	N. 1 46	N. 2 7	17 40
7 40	N. 1 25	N. 1 30	N. 1 37	N. 1 50	N. 2 11	18 10
7 10	N. 1 25	N. 1 30	N. 1 38	N. 1 51	N. 2 12	18 40

TABLE III.—DECLINATION.

Apparent Time.	0° 0′		0° 30′		1° 0′		1° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	0 0	8·2419	0 30	8·2419	1 0	8·2418	1 30	8·2418	12 4
11 52	0 0	8·5431	0 30	8·5431	1 0	8·5430	1 30	8·5430	12 8
11 48	0 0	8·7194	0 30	8·7194	1 0	8·7193	1 30	8·7193	12 12
11 44	0 0	8·8446	0 30	8·8446	1 0	8·8445	1 30	8·8445	12 16
11 40	0 0	8·9420	0 30	8·9420	1 0	8·9419	1 30	8·9419	12 20
11 36	0 0	9·0216	0 30	9·0216	1 0	9·0215	1 30	9·0215	12 24
11 32	0 0	9·0891	0 30	9·0891	1 0	9·0890	1 30	9·0890	12 28
11 28	0 0	9·1478	0 30	9·1478	1 0	9·1477	1 30	9·1477	12 32
11 24	0 0	9·1997	0 30	9·1997	1 0	9·1996	1 30	9·1996	12 36
11 20	0 0	9·2463	0 30	9·2463	1 0	9·2462	1 31	9·2462	12 40
11 16	0 0	9·2887	0 30	9·2887	1 1	9·2886	1 31	9·2886	12 44
11 12	0 0	9·3275	0 30	9·3275	1 1	9·3274	1 31	9·3274	12 48
11 8	0 0	9·3634	0 31	9·3634	1 1	9·3633	1 32	9·3633	12 52
11 4	0 0	9·3968	0 31	9·3968	1 2	9·3967	1 32	9·3967	12 56
11 0	0 0	9·4281	0 31	9·4281	1 2	9·4280	1 33	9·4280	1 0
10 56	0 0	9·4575	0 31	9·4575	1 2	9·4574	1 34	9·4574	1 4
10 52	0 0	9·4854	0 31	9·4854	1 3	9·4853	1 34	9·4852	1 8
10 48	0 0	9·5118	0 32	9·5118	1 3	9·5117	1 35	9·5117	1 12
10 44	0 0	9·5370	0 32	9·5370	1 4	9·5369	1 35	9·5369	1 16
10 40	0 0	9·5611	0 32	9·5611	1 4	9·5610	1 36	9·5610	1 20
10 36	0 0	9·5842	0 32	9·5842	1 5	9·5841	1 37	9·5841	1 24
10 32	0 0	9·6064	0 32	9·6064	1 5	9·6063	1 37	9·6063	1 28
10 28	0 0	9·6279	0 33	9·6279	1 6	9·6278	1 38	9·6278	1 32
10 24	0 0	9·6486	0 33	9·6486	1 6	9·6485	1 40	9·6485	1 36
10 20	0 0	9·6687	0 33	9·6687	1 7	9·6686	1 40	9·6685	1 40
10 16	0 0	9·6882	0 33	9·6882	1 7	9·6882	1 41	9·6880	1 44
10 12	0 0	9·7072	0 34	9·7072	1 8	9·7071	1 42	9·7070	1 48
10 8	0 0	9·7257	0 34	9·7257	1 8	9·7256	1 43	9·7255	1 52
10 4	0 0	9·7438	0 34	9·7438	1 8	9·7437	1 43	9·7436	1 56
10 0	0 0	9·7614	0 35	9·7614	1 9	9·7613	1 44	9·7612	2 0
9 56	0 0	9·7787	0 35	9·7787	1 9	9·7786	1 45	9·7785	2 4
9 52	0 0	9·7957	0 35	9·7957	1 10	9·7956	1 46	9·7955	2 8
9 48	0 0	9·8125	0 35	9·8125	1 11	9·8124	1 47	9·8123	2 12
9 44	0 0	9·8290	0 36	9·8290	1 12	9·8289	1 49	9·8288	2 16
9 40	0 0	9·8452	0 36	9·8452	1 13	9·8451	1 50	9·8450	2 20
9 36	0 0	9·8613	0 37	9·8613	1 14	9·8612	1 52	9·8611	2 24
9 32	0 0	9·8771	0 37	9·8771	1 15	9·8770	1 53	9·8769	2 28
9 28	0 0	9·8928	0 38	9·8928	1 17	9·8927	1 55	9·8925	2 32
9 24	0 0	9·9084	0 39	9·9084	1 18	9·9083	1 56	9·9080	2 36
9 20	0 0	9·9238	0 40	9·9238	1 19	9·9237	1 58	9·9235	2 40
9 16	0 0	9·9392	0 40	9·9392	1 21	9·9391	2 0	9·9390	2 44
9 12	0 0	9·9544	0 41	9·9544	1 22	9·9543	2 2	9·9542	2 48
9 8	0 0	9·9697	0 41	9·9697	1 23	9·9696	2 4	9·9695	2 52
9 4	0 0	9·9848	0 42	9·9848	1 24	9·9847	2 6	9·9846	2 56
9 0	0 0	10·0000	0 43	10·0000	1 25	9·9999	2 8	9·9998	3 0

TABLE III.—DECLINATION.

Apparent Time.	0° 0′		0° 30′		1° 0′		1° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	0 0	10·0152	0 43	10·0152	1 26	10·0151	2 10	10·0149	3 4
8 52	0 0	10·0303	0 44	10·0303	1 28	10·0302	2 12	10·0300	3 8
8 48	0 0	10·0456	0 45	10·0456	1 30	10·0455	2 15	10·0453	3 12
8 44	0 0	10·0608	0 46	10·0608	1 31	10·0607	2 17	10·0605	3 16
8 40	0 0	10·0762	0 47	10·0762	1 33	10·0761	2 20	10·0759	3 20
8 36	0 0	10·0916	0 48	10·0915	1 35	10·0914	2 23	10·0912	3 24
8 32	0 0	10·1072	0 49	10·1071	1 37	10·1070	2 26	10·1068	3 28
8 28	0 0	10·1229	0 50	10·1228	1 39	10·1227	2 29	10·1225	3 32
8 24	0 0	10·1387	0 51	10·1386	1 41	10·1385	2 33	10·1382	3 36
8 20	0 0	10·1548	0 52	10·1547	1 44	10·1546	2 37	10·1543	3 40
8 16	0 0	10·1710	0 54	10·1709	1 47	10·1708	2 41	10·1705	3 44
8 12	0 0	10·1875	0 55	10·1874	1 50	10·1873	2 46	10·1870	3 48
8 8	0 0	10·2042	0 57	10·2041	1 53	10·2040	2 50	10·2037	3 52
8 4	0 0	10·2212	0 58	10·2211	1 56	10·2210	2 55	10·2207	3 56
8 0	0 0	10·2386	1 0	10·2385	2 0	10·2383	3 0	10·2379	4 0
7 56	0 0	10·2562	1 2	10·2561	2 4	10·2559	3 6	10·2555	4 4
7 52	0 0	10·2743	1 4	10·2742	2 8	10·2740	3 12	10·2736	4 8
7 48	0 0	10·2928	1 6	10·2927	2 12	10·2925	3 18	10·2920	4 12
7 44	0 0	10·3118	1 9	10·3117	2 17	10·3115	3 25	10·3110	4 16
7 40	0 0	10·3313	1 11	10·3311	2 22	10·3309	3 33	10·3304	4 20
7 36	0 0	10·3514	1 14	10·3512	2 27	10·3510	3 41	10·3504	4 24
7 32	0 0	10·3721	1 17	10·3719	2 33	10·3717	3 50	10·3711	4 28
7 28	0 0	10·3936	1 20	10·3934	2 40	10·3932	4 0	10·3925	4 32
7 24	0 0	10·4158	1 24	10·4156	2 47	10·4153	4 11	10·4145	4 36
7 20	0 0	10·4389	1 28	10·4387	2 55	10·4384	4 23	10·4375	4 40
7 16	0 0	10·4630	1 32	10·4627	3 4	10·4624	4 37	10·4615	4 44
7 12	0 0	10·4882	1 37	10·4879	3 14	10·4875	4 51	10·4865	4 48
7 8	0 0	10·5147	1 43	10·5144	3 25	10·5139	5 7	10·5128	4 52
7 4	0 0	10·5425	1 49	10·5422	3 37	10·5416	5 26	10·5404	4 56
7 0	0 0	10·5719	1 56	10·5716	3 51	10·5709	5 46	10·5695	5 0
6 56	0 0	10·6032	2 4	10·6029	4 8	10·6021	6 11	10·6007	5 4
6 52	0 0	10·6366	2 13	10·6363	4 26	10·6353	6 38	10·6337	5 8
6 48	0 0	10·6725	2 24	10·6721	4 48	10·6710	7 11	10·6691	5 12
6 44	0 0	10·7113	2 37	10·7108	5 13	10·7095	7 49	10·7072	5 16
6 40	0 0	10·7537	2 53	10·7531	5 44	10·7515	8 35	10·7488	5 20
6 36	0 0	10·8003	3 12	10·7996	6 22	10·7976	9 32	10·7943	5 24
6 32	0 0	10·8522	3 35	10·8513	7 9	10·8488	10 39	10·8446	5 28
6 28	0 0	10·9109	4 6	10·9099	8 9	10·9065	12 8	10·9016	5 32
6 24	0 0	10·9784	4 46	10·9773	9 29	10·9724	14 4	10·9652	5 36
6 20	0 0	11·0581	5 43	11·0566	11 19	11·0495	16 45	11·0395	5 40
6 16	0 0	11·1554	7 8	11·1532	14 3	11·1422	20 35	11·1267	5 44
6 12	0 0	11·2806	9 28	11·2772	18 26	11·2577	26 35	11·2311	5 48
6 8	0 0	11·4569	14 2	11·4509	26 34	11·4074	36 53	11·3599	5 52
6 4	0 0	11·7581	26 34	11·7097	45 0	11·5976	56 41	11·5021	5 56
6 0	0 0	*Infinite.*	90 0	12·0591	90 0	11·7581	90 0	11·5819	6

TABLE III.—DECLINATION.

Apparent Time.	2° 0′		2° 30′		3° 0′		3° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I	Log. I.	Arc I.	Log. I.	Arc 1.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	2 0	8·2416	2 30	8·2415	3 0	8·2415	3 30	8·2411	12 4
11 52	2 0	8·5428	2 30	8·5427	3 0	8·5425	3 30	8·5423	12 8
11 48	2 0	8·7191	2 30	8·7190	3 0	8·7188	3 30	8·7186	12 12
11 44	2 0	8·8443	2 30	8·8442	3 0	8·8440	3 30	8·8438	12 16
11 40	2 0	8·9417	2 30	8·9416	3 0	8·9414	3 30	8·9412	12 20
11 36	2 0	9·0213	2 31	9·0212	3 1	9·0210	3 31	9·0208	12 24
11 32	2 0	9·0888	2 31	9·0887	3 2	9·0885	3 32	9·0883	12 28
11 28	2 0	9·1475	2 31	9·1474	3 2	9·1472	3 32	9·1470	12 32
11 24	2 1	9·1994	2 31	9·1993	3 3	9·1991	3 33	9·1988	12 36
11 20	2 1	9·2460	2 31	9·2459	3 3	9·2457	3 33	9·2454	12 40
11 16	2 2	9·2884	2 32	9·2883	3 4	9·2881	3 34	9·2878	12 44
11 12	2 2	9·3272	2 32	9·3271	3 4	9·3269	3 35	9·3266	12 48
11 8	2 2	9·3631	2 33	9·3630	3 5	9·3628	3 36	9·3625	12 52
11 4	2 3	9·3965	2 34	9.3964	3 5	9·3962	3 36	9·3959	12 56
11 0	2 4	9·4278	2 35	9·4277	3 6	9·4275	3 37	9·4272	1 0
10 56	2 6	9·4572	2 36	9·4571	3 7	9·4569	3 38	9·4566	1 4
10 52	2 6	9·4850	2 37	9·4849	3 8	9·4848	3 39	9·4845	1 8
10 48	2 6	9·5115	2 38	9·5114	3 9	9·5111	3 40	9·5108	1 12
10 44	2 7	9·5367	2 39	9·5366	3 10	9·5363	3 42	9.5360	1 16
10 40	2 8	9·5608	2 40	9·5607	3 11	9·5604	3 43	9·5601	1 20
10 36	2 9	9·5839	2 42	9·5838	3 13	9·5835	3 45	9·5832	1 24
10 32	2 10	9·6061	2 43	9·6060	3 14	9·6057	3 46	9·6054	1 28
10 28	2 11	9·6276	2 44	9·6275	3 16	9·6272	3 47	9·6269	1 32
10 24	2 13	9·6483	2 46	9·6482	3 17	9·6479	3 48	9·6476	1 36
10 20	2 13	9·6684	2 47	9·6682	3 18	9·6680	3 50	9·6676	1 40
10 16	2 14	9·6879	2 48	9·6877	3 20	9·6875	3 52	9·6871	1 44
10 12	2 16	9·7069	2 50	9·7067	3 22	9·7065	3 55	9·7061	1 48
10 8	2 17	9·7254	2 51	9·7252	3 23	9·7249	3 57	9·7245	1 52
10 4	2 18	9·7435	2 52	9·7433	3 24	9·7430	3 58	9·7426	1 56
10 0	2 19	9·7611	2 54	9·7609	3 26	9·7606	4 1	9·7602	2 0
9 56	2 20	9·7784	2 55	9·7783	3 28	9·7779	4 4	9·7775	2 4
9 52	2 22	9·7953	2 57	9·7952	3 31	9·7949	4 6	9·7945	2 8
9 48	2 23	9·8121	2 58	9·8120	3 34	9·8117	4 9	9·8113	2 12
9 44	2 25	9·8286	3 0	9·8284	3 37	9·8281	4 13	9·8277	2 16
9 40	2 26	9·8448	3 1	9·8446	3 40	9·8443	4 17	9·8439	2 20
9 36	2 28	9·8609	3 2	9·8607	3 43	9·8604	4 20	9·8600	2 24
9 32	2 30	9·8767	3 3	9·8764	3 46	9·8761	4 23	9·8757	2 28
9 28	2 32	9·8924	3 5	9·8923	3 49	9·8918	4 26	9·8914	2 32
9 24	2 34	9·9079	3 6	9·9078	3 52	9·9074	4 31	9·9070	2 36
9 20	2 37	9·9233	3 8	9·9231	3 55	9·9228	4 34	9·9224	2 40
9 16	2 39	9·9387	3 9	9·9384	3 59	9·9381	4 38	9·9377	2 44
9 12	2 41	9·9539	3 11	9·9536	4 3	9·9533	4 43	9·9529	2 48
9 8	2 44	9·9692	3 12	9·9689	4 7	9·9685	4 47	9·9681	2 52
9 4	2 47	9·9843	3 13	9·9840	4 11	9·9836	4 52	9·9822	2 56
9 0	2 50	9·9995	3 16	9·9992	4 15	9·9988	4 57	9·9973	3 0

TABLE III.—DECLINATION.

Apparent Time.	2° 0′		2° 30′		3° 0′		3° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	2 53	10·0147	3 36	10·0144	4 19	10·0140	5 1	10·0135	3 4
8 52	2 56	10·0297	3 40	10·0294	4 24	10·0290	5 7	10·0286	3 8
8 48	2 59	10·0450	3 44	10·0447	4 29	10·0443	5 13	10·0438	3 12
8 44	3 2	10·0602	3 48	10·0598	4 34	10·0594	5 19	10·0589	3 16
8 40	3 6	10·0755	3 53	10·0752	4 40	10·0748	5 26	10·0742	3 20
8 36	3 10	10·0909	3 58	10·0905	4 46	10·0901	5 33	10·0895	3 24
8 32	3 15	10·1065	4 4	10·1061	4 52	10·1056	5 39	10·1050	3 28
8 28	3 20	10·1222	4 10	10·1218	4 59	10·1213	5 50	10·1207	3 32
8 24	3 25	10·1379	4 16	10·1375	5 6	10·1370	5 56	10·1364	3 36
8 20	3 30	10·1540	4 22	10·1535	5 13	10·1530	6 7	10·1523	3 40
8 16	3 35	10·1702	4 28	10·1697	5 21	10·1681	6 16	10·1674	3 44
8 12	3 41	10·1866	4 36	10·1861	5 30	10·1855	6 25	10·1847	3 48
8 8	3 47	10·2033	4 43	10·2027	5 39	10·2021	6 35	10·2013	3 52
8 4	3 53	10·2202	4 51	10·2196	5 48	10·2190	6 47	10·2182	3 56
8 0	4 0	10·2375	5 0	10·2369	5 59	10·2363	6 59	10·2354	4 0
7 56	4 7	10·2551	5 9	10·2544	6 10	10·2537	7 12	10·2527	4 4
7 52	4 15	10·2731	5 19	10·2724	6 22	10·2716	7 26	10·2706	4 8
7 48	4 24	10·2915	5 30	10·2907	6 35	10·2899	7 40	10·2888	4 12
7 44	4 33	10·3104	5 41	10·3095	6 49	10·3087	7 56	10·3075	4 16
7 40	4 43	10·3298	5 54	10·3289	7 4	10·3280	8 13	10·3267	4 20
7 36	4 54	10·3498	6 8	10·3488	7 21	10·3478	8 33	10·3465	4 24
7 32	5 6	10·3704	6 22	10·3693	7 38	10·3682	8 54	10·3667	4 28
7 28	5 19	10·3918	6 39	10·3906	7 58	10·3894	9 17	10·3878	4 32
7 24	5 34	10·4137	6 57	10·4125	8 19	10·4112	9 41	10·4095	4 36
7 20	5 50	10·4366	7 17	10·4353	8 43	10·4339	10 8	10·4320	4 40
7 16	6 8	10·4605	7 40	10·4590	9 9	10·4474	10 39	10·4553	4 44
7 12	6 27	10·4854	8 3	10·4837	9 38	10·4820	11 12	10·4797	4 48
7 8	6 49	10·5116	8 30	10·5097	10 10	10·5078	11 49	10·5052	4 52
7 4	7 13	10·5391	8 55	10·5371	10 46	10·5348	12 30	10·5319	4 56
7 0	7 41	10·5680	9 34	10·5656	11 27	10·5632	13 17	10·5600	5 0
6 56	8 13	10·5988	10 14	10·5962	12 13	10·5932	14 10	10·5895	5 4
6 52	8 49	10·6314	10 59	10·6286	13 7	10·6251	15 11	10·6210	5 8
6 48	9 32	10·6665	11 51	10·6631	14 9	10·6591	16 22	10·6542	5 12
6 44	10 22	10·7041	12 53	10·7002	15 22	10·6955	17 46	10·6901	5 16
6 40	11 22	10·7451	14 7	10·7404	16 47	10·7348	19 24	10·7283	5 20
6 36	12 35	10·7897	15 36	10·7840	18 31	10·7772	21 21	10·7694	5 24
6 32	14 5	10·8389	17 25	10·8359	20 38	10·8234	23 43	10·8139	5 28
6 28	15 59	10·8938	19 42	10·8847	23 16	10·8741	26 39	10·8621	5 32
6 24	18 28	10·9554	22 40	10·9435	26 38	10·9297	30 20	10·9135	5 36
6 20	21 50	11·0255	26 36	11·0095	31 1	10·9910	35 3	10·9711	5 40
6 16	26 36	11·1068	32 2	11·0836	36 16	11·0619	41 18	11·0311	5 44
6 12	33 43	11·2006	39 50	11·1659	45 2	11·1298	49 31	11·0830	5 48
6 8	45 5	11·3058	51 22	11·2523	56 20	11·2007	60 21	11·1512	5 52
6 4	63 27	11·4280	68 12	11·3277	71 35	11·2577	74 4	11·1966	5 56
6 0	90 0	11·4569	90 0	11·3599	90 0	11·2806	90 0	11·2135	6 0

TABLE III.—DECLINATION.

Apparent Time.	4° 0′		4° 30′		5° 0′		5° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	4 0	8·2407	4 30	8·2404	5 0	8·2401	5 30	8·2398	12 4
11 52	4 0	8·5419	4 30	8·5416	5 0	8·5413	5 30	8·5410	12 8
11 48	4 0	8·7182	4 30	8·7179	5 0	8·7176	5 30	8·7173	12 12
11 44	4 0	8·8434	4 30	8·8431	5 0	8·8428	5 31	8·8425	12 16
11 40	4 1	8·9408	4 31	8·9405	5 1	8·9402	5 31	8·9399	12 20
11 36	4 1	9·0204	4 31	9·0201	5 2	9·0197	5 32	9·0194	12 24
11 32	4 2	9·0879	4 32	9·0876	5 2	9·0872	5 32	9·0869	12 28
11 28	4 2	9·1472	4 32	9·1469	5 3	9·1465	5 33	9·1462	12 32
11 24	4 3	9·1984	4 33	9·1981	5 4	9·1977	5 34	9·1974	12 36
11 20	4 3	9·2450	4 34	9·2447	5 4	9·2443	5 35	9·2440	12 40
11 16	4 4	9·2874	4 35	9·2871	5 5	9·2867	5 36	9·2864	12 44
11 12	4 5	9·3262	4 36	9·3259	5 6	9·3255	5 37	9·3252	12 48
11 8	4 6	9·3621	4 37	9·3618	5 7	9·3614	5 38	9·3611	12 52
11 4	4 7	9·3955	4 38	9·3952	5 9	9·3938	5 40	9·3935	12 56
11 0	4 8	9·4268	4 40	9·4265	5 11	9·4261	5 42	9·4258	1 0
10 56	4 9	9·4562	4 42	9·4559	5 13	9·4555	5 43	9·4552	1 4
10 52	4 11	9·4841	4 43	9·4838	5 14	9·4834	5 45	9·4831	1 8
10 48	4 12	9·5104	4 44	9·5101	5 16	9·5097	5 47	9·5094	1 12
10 44	4 13	9·5356	4 45	9·5353	5 17	9·5348	5 49	9·5345	1 16
10 40	4 13	9·5597	4 47	9·5594	5 19	9·5590	5 51	9·5587	1 20
10 36	4 15	9·5828	4 48	9·5825	5 20	9·5820	5 53	9·5817	1 24
10 32	4 17	9·6050	4 50	9·6047	5 23	9·6043	5 55	9·6039	1 28
10 28	4 19	9·6264	4 53	9·6261	5 26	9·6257	5 58	9·6253	1 32
10 24	4 21	9·6471	4 55	9·6468	5 28	9·6464	6 1	9·6460	1 36
10 20	4 23	9·6671	4 56	9·6668	5 31	9·6664	6 4	9·6660	1 40
10 16	4 25	9·6866	4 58	9·6863	5 33	9·6859	6 7	9·6855	1 44
10 12	4 28	9·7056	5 2	9·7053	5 36	9·7047	6 10	9·7043	1 48
10 8	4 32	9·7240	5 5	9·7237	5 39	9·7233	6 13	9·7229	1 52
10 4	4 33	9·7421	5 8	9·7417	5 42	9·7413	6 17	9·7409	1 56
10 0	4 36	9·7597	5 12	9·7593	5 47	9·7589	6 21	9·7585	2 0
9 56	4 40	9·7770	5 16	9·7766	5 51	9·7762	6 25	9·7758	2 4
9 52	4 42	9·7940	5 19	9·7936	5 54	9·7932	6 29	9·7927	2 8
9 48	4 45	9·8108	5 22	9·8104	5 58	9·8100	6 33	9·8095	2 12
9 44	4 49	9·8272	5 25	9·8268	6 2	9·8264	6 39	9·8259	2 16
9 40	4 53	9·8434	5 29	9·8430	6 6	9·8426	6 43	9·8421	2 20
9 36	4 57	9·8595	5 34	9·8591	6 12	9·8587	6 50	9·8582	2 24
9 32	5 0	9·8752	5 37	9·8748	6 15	9·8744	6 54	9·8739	2 28
9 28	5 4	9·8909	5 42	9·8905	6 20	9·8901	6 58	9·8896	2 32
9 24	5 8	9·9065	5 46	9·9061	6 25	9·9056	7 2	9·9051	2 36
9 20	5 13	9·9219	5 52	9·9215	6 31	9·9210	7 8	9·9204	2 40
9 16	5 18	9·9372	5 57	9·9368	6 37	9·9363	7 17	9·9357	2 44
9 12	5 23	9·9524	6 3	9·9520	6 43	9·9514	7 23	9·9508	2 48
9 8	5 28	9·9676	6 8	9·9672	6 49	9·9666	7 29	9·9660	2 52
9 4	5 33	9·9817	6 14	9·9813	6 55	9·9807	7 36	9·9801	2 56
9 0	*5 39*	9·9968	6 21	9·9963	7 3	9·9957	7 45	9·9951	3 0

TABLE III.—DECLINATION.

Apparent Time.	4° 0′		4° 30′		5° 0′		5° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	5 43	10·0130	6 27	10·0124	7 10	10·0118	7 53	10·0111	3 4
8 52	5 49	10·0281	6 34	10·0275	7 19	10·0268	8 3	10·0260	3 8
8 48	5 47	10·0433	6 42	10·0427	7 27	10·0419	8 13	10·0411	3 12
8 44	6 5	10·0583	6 50	10·0577	7 36	10·0570	8 21	10·0562	3 16
8 40	6 12	10·0736	6 59	10·0729	7 45	10·0722	8 31	10·0714	3 20
8 36	6 20	10·0889	7 8	10·0882	7 55	10·0874	8 42	10·0865	3 24
8 32	6 29	10·1044	7 17	10·1037	8 5	10·1029	8 53	10·1020	3 28
8 28	6 38	10·1200	7 27	10·1192	8 16	10·1184	9 5	10·1174	3 32
8 24	6 47	10·1357	7 38	10·1349	8 28	10·1340	9 18	10·1330	3 36
8 20	6 57	10·1516	7 50	10·1507	8 40	10·1498	9 32	10·1487	3 40
8 16	7 8	10·1667	8 2	10·1661	8 54	10·1654	9 47	10·1647	3 44
8 12	7 19	10·1839	8 14	10·1830	9 8	10·1820	10 2	10·1808	3 48
8 8	7 31	10·2005	8 28	10·1995	9 23	10·1984	10 18	10·1971	3 52
8 4	7 43	10·2174	8 42	10·2162	9 39	10·2140	10 36	10·2127	3 56
8 0	7 57	10·2344	8 57	10·2332	9 56	10·2321	10 54	10·2307	4 0
7 56	8 12	10·2517	9 14	10·2505	10 12	10·2493	11 13	10·2478	4 4
7 52	8 28	10·2695	9 32	10·2682	10 33	10·2669	11 35	10·2653	4 8
7 48	8 45	10·2877	9 50	10·2864	10 54	10·2849	11 58	10·2832	4 12
7 44	9 4	10·3063	10 11	10·3048	11 17	10·3033	12 23	10·3015	4 16
7 40	9 24	10·3254	10 33	10·3238	11 42	10·3222	12 50	10·3203	4 20
7 36	9 45	10·3451	10 57	10·3434	12 8	10·3416	13 18	10·3395	4 24
7 32	10 9	10·3653	11 23	10·3634	12 37	10·3615	13 50	10·3592	4 28
7 28	10 35	10·3862	11 52	10·3842	13 9	10·3821	14 25	10·3797	4 32
7 24	11 2	10·4077	12 23	10·4055	13 43	10·4032	15 2	10·4006	4 36
7 20	11 33	10·4300	12 57	10·4276	14 21	10·4251	15 41	10·4222	4 40
7 16	12 7	10·4532	13 35	10·4506	15 2	10·4479	16 23	10·4447	4 44
7 12	12 45	10·4774	14 17	10·4745	15 48	10·4715	17 18	10·4680	4 48
7 8	13 27	10·5026	15 4	10·4994	16 40	10·4961	18 13	10·4922	4 52
7 4	14 14	10·5290	15 56	10·5254	17 37	10·5217	19 15	10·5174	4 56
7 0	15 7	10·5566	16 54	10·5525	18 40	10·5484	20 23	10·5436	5 0
6 56	16 7	10·5858	18 0	10·5812	19 52	10·5765	21 41	10·5711	5 4
6 52	17 15	10·6166	19 15	10·6114	21 14	10·6061	23 7	10·5995	5 8
6 48	18 35	10·6492	20 42	10·6432	22 49	10·6371	24 49	10·6301	5 12
6 44	20 7	10·6840	22 25	10·6772	24 38	10·6699	26 46	10·6620	5 16
6 40	21 56	10·7211	24 23	10·7131	26 44	10·7046	29 0	10·6955	5 20
6 36	24 5	10·7607	26 42	10·7513	29 13	10·7412	31 37	10·7304	5 24
6 32	26 40	10·8033	29 29	10·7919	32 9	10·7799	34 40	10·7633	5 28
6 28	29 50	10·8491	32 51	10·8352	35 40	10·8206	38 19	10·8060	5 32
6 24	33 47	10·8971	36 59	10·8799	39 56	10·8631	42 39	10·8472	5 36
6 20	38 44	10·9501	42 5	10·9285	45 7	10·9066	47 51	10·8849	5 40
6 16	45 4	11·0044	48 27	10·9771	51 25	10·9503	54 4	10·9270	5 44
6 12	53 11	11·0582	56 22	11·0238	59 7	10·9910	61 28	10·9607	5 48
6 8	63 28	11·1068	66 5	11·0648	68 15	11·0258	70 4	10·9884	5 52
6 4	75 59	11·1423	77 30	11·0936	78 43	11·0496	79 43	11·0084	5 56
6 0	90 0	11·1554	90 0	11·1040	90 0	11·0580	90 0	11·0164	6 0

TABLE III.—DECLINATION.

Apparent Time.	6° 0′		6° 30′		7° 0′		7° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	6 0	8·2395	6 30	8·2391	7 0	8·2387	7 30	8·2383	12 4
11 52	6 0	8·5407	6 30	8·5403	7 0	8·5389	7 30	8·5385	12 8
11 48	6 0	8·7170	6 30	8·7166	7 0	8·7162	7 31	8·7158	12 12
11 44	6 1	8·8422	6 31	8·8418	7 1	8·8414	7 31	8·8410	12 16
11 40	6 1	8·9396	6 31	8·9392	7 2	8·9388	7 32	8·9384	12 20
11 36	6 2	9·0192	6 32	9·0188	7 3	9·0184	7 33	9·0180	12 24
11 32	6 2	9·0867	6 33	9·0863	7 3	9·0859	7 34	9·0855	12 28
11 28	6 3	9·1454	6 34	9·1450	7 4	9·1446	7 35	9·1442	12 32
11 24	6 4	9·1973	6 35	9·1969	7 5	9·1965	7 36	9·1960	12 36
11 20	6 5	9·2438	6 36	9·2434	7 6	9·2430	7 37	9·2425	12 40
11 16	6 7	9·2862	6 37	9·2858	7 8	9·2854	7 38	9·2849	12 44
11 12	6 8	9·3250	6 39	9·3246	7 10	9·3242	7 40	9·3237	12 48
11 8	6 9	9·3609	6 41	9·3605	7 11	9·3601	7 42	9·3596	12 52
11 4	6 11	9·3942	6 43	9·3938	7 12	9·3934	7 44	9·3929	12 56
11 0	6 13	9·4255	6 45	9·4251	7 14	9·4246	7 47	9·4241	1 0
10 56	6 14	9·4549	6 47	9·4545	7 16	9·4540	7 49	9·4535	1 4
10 52	6 16	9·4828	6 48	9·4824	7 18	9·4819	7 51	9·4814	1 8
10 48	6 18	9·5092	6 50	9·5088	7 20	9·5083	7 53	9·5078	1 12
10 44	6 20	9·5344	6 52	9·5340	7 23	9·5335	7 56	9·5330	1 16
10 40	6 22	9·5585	6 55	9·5580	7 26	9·5575	7 59	9·5570	1 20
10 36	6 25	9·5815	6 58	9·5810	7 29	9·5805	8 2	9·5799	1 24
10 32	6 28	9·6037	7 1	9·6032	7 33	9·6027	8 6	9·6021	1 28
10 28	6 31	9·6251	7 4	9·6246	7 36	9·6241	8 9	9·6235	1 32
10 24	6 34	9·6457	7 7	9·6452	7 40	9·6447	8 13	9·6441	1 36
10 20	6 37	9·6658	7 10	9·6653	7 43	9·6648	8 16	9·6642	1 40
10 16	6 40	9·6852	7 13	9·6847	7 47	9·6842	8 20	9·6836	1 44
10 12	6 44	9·7042	7 17	9·7037	7 51	9·7031	8 24	9·7025	1 48
10 8	6 47	9·7226	7 21	9·7221	7 55	9·7215	8 29	9·7209	1 52
10 4	6 51	9·7407	7 25	9·7402	8 0	9·7396	8 33	9·7390	1 56
10 0	6 55	9·7582	7 30	9·7577	8 4	9·7571	8 39	9·7565	2 0
9 56	6 59	9·7753	7 34	9·7748	8 9	9·7743	8 44	9·7736	2 4
9 52	7 4	9·7924	7 39	9·7918	8 14	9·7912	8 50	9·7905	2 8
9 48	7 9	9·8091	7 44	9·8085	8 20	9·8079	8 56	9·8072	2 12
9 44	7 13	9·8255	7 49	9·8249	8 25	9·8243	9 1	9·8236	2 16
9 40	7 19	9·8417	7 55	9·8412	8 31	9·8404	9 8	9·8397	2 20
9 36	7 24	9·8577	8 1	9·8571	8 38	9·8564	9 15	9·8556	2 24
9 32	7 30	9·8724	8 7	9·8720	8 44	9·8715	9 22	9·8710	2 28
9 28	7 36	9·8890	8 13	9·8883	8 51	0·8876	9 29	9·8868	2 32
9 24	7 42	9·9045	8 20	9·9038	8 59	9·9030	9 37	9·9022	2 36
9 20	7 49	9·9198	8 27	9·9191	9 6	9·9183	9 45	9·9175	2 40
9 16	7 56	9·9350	8 35	9·9343	9 14	9·9335	9 54	9·9327	2 44
9 12	8 3	9·9501	8 43	9·9494	9 23	9·9486	10 3	9·9477	2 48
9 8	8 11	9·9653	8 51	9·9644	9 32	9·9637	10 13	9·6627	2 52
9 4	8 19	9·9802	9 0	9·9794	9 41	9·9786	10 22	9·9776	2 56
9 0	8 27	9·9953	9 9	9·9945	9 51	9·9936	10 33	9·9926	3 0

TABLE III.—DECLINATION.

Apparent Time.	6° 0′		6° 30′		7° 0′		7° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	8 36	10·0103	9 20	10·0094	10 3	10·0085	10 45	10·0075	3 4
8 52	8 46	10·0252	9 29	10·0243	10 12	10·0234	10 56	10·0224	3 8
8 48	8 56	10·0403	9 40	10·0394	10 24	10·0384	11 8	10·0373	3 12
8 44	9 6	10·0554	9 52	10·0545	10 36	10·0533	11 21	10·0522	3 16
8 40	9 17	10·0705	10 4	10·0695	10 49	10·0684	11 35	10·0673	3 20
8 36	9 29	10·0856	10 16	10·0846	11 2	10·0835	11 49	10·0823	3 24
8 32	9 41	10·1010	10 29	10·0999	11 17	10·0987	12 4	10·0975	3 28
8 28	9 54	10·1164	10 43	10·1153	11 32	10·1140	12 20	10·1128	3 32
8 24	10 8	10·1319	10 58	10·1307	11 48	10·1294	12 38	10·1281	3 36
8 20	10 23	10·1476	11 14	10·1464	12 5	10·1451	12 56	10·1436	3 40
8 16	10 39	10·1635	11 31	10·1622	12 23	10·1608	13 15	10·1593	3 44
8 12	10 55	10·1796	11 49	10·1782	12 42	10·1767	13 35	10·1751	3 48
8 8	11 13	10·1958	12 9	10·1943	13 2	10·1929	13 57	10·1912	3 52
8 4	11 32	10·2123	12 29	10·2107	13 24	10·2092	14 20	10·2074	3 56
8 0	11 52	10·2292	12 50	10·2276	13 48	10·2259	14 45	10·2240	4 0
7 56	12 14	10·2462	13 14	10·2445	14 12	10·2427	15 11	10·2407	4 4
7 52	12 37	10·2637	13 39	10·2618	14 39	10·2599	15 40	10·2578	4 8
7 48	13 2	10·2815	14 5	10·2795	15 8	10·2775	16 10	10·2752	4 12
7 44	13 29	10·2997	14 35	10·2976	15 39	10·2954	16 42	10·2929	4 16
7 40	13 58	10·3183	15 7	10·3160	16 12	10·3137	17 18	10·3111	4 20
7 36	14 29	10·3374	15 39	10·3350	16 48	10·3325	17 56	10·3297	4 24
7 32	15 3	10·3569	16 15	10·3543	17 26	10·3517	18 38	10·3487	4 28
7 28	15 40	10·3772	16 54	10·3744	18 8	10·3715	19 23	10·3685	4 32
7 24	16 20	10·3979	17 37	10·3948	18 54	10·3917	20 10	10·3882	4 36
7 20	17 5	10·4193	18 25	10·4159	19 44	10·4126	21 2	10·4085	4 40
7 16	17 53	10·4415	19 17	10·4378	20 40	10·4341	22 0	10·4297	4 44
7 12	18 47	10·4644	20 14	10·4604	21 40	10·4564	23 4	10·4519	4 48
7 8	19 46	10·4883	21 17	10·4840	22 47	10·4794	24 11	10·4730	4 52
7 4	20 52	10·5130	22 27	10·5082	24 0	10·5032	25 30	10·4974	4 56
7 0	22 6	10·5388	23 45	10·5334	25 22	10·5278	26 56	10·5218	5 0
6 56	23 29	10·5657	25 13	10·5597	26 54	10·5535	28 30	10·5456	5 4
6 52	25 2	10·5938	26 50	10·5870	28 37	10·5800	30 18	10·5705	5 8
6 48	26 49	10·6231	28 24	10·6155	30 33	10·6076	32 18	10·6006	5 12
6 44	28 50	10·6538	30 51	10·6450	32 45	10·6361	34 35	10·6262	5 16
6 40	31 11	10·6849	33 13	10·6753	35 15	10·6657	37 8	10·6557	5 20
6 36	33 53	10·7194	36 0	10·7078	38 7	10·6961	40 2	10·6839	5 24
6 32	37 3	10·7543	39 18	10·7409	41 25	10·7272	43 22	10·7134	5 28
6 28	40 46	10·7902	43 4	10·7745	45 16	10·7589	47 11	10·7431	5 32
6 24	45 9	10·8267	47 28	10·8084	49 35	10·7902	51 28	10·7722	5 36
6 20	50 20	10·8630	52 35	10·8416	54 38	10·8206	56 25	10·7998	5 40
6 16	56 25	10·8981	58 31	10·8732	60 23	10·8494	62 0	10·8264	5 44
6 12	63 32	10·9296	65 20	10·9011	66 20	10·8825	67 58	10·8479	5 48
6 8	71 38	10·9554	72 58	10·9237	74 8	10·8938	75 6	10·8664	5 52
6 4	80 35	10·9727	81 17	10·9382	81 55	10·9066	82 25	10·8777	5 56
6 0	90 0	10·9784	90 0	10·9433	90 0	10·9109	90 0	10·8806	6 0

TABLE III.—DECLINATION.

Apparent Time	8° 0′		8° 30′		9° 0′		9° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	8 0	8·2376	8 30	8·2371	9 0	8·2365	9 30	8·2359	12 4
11 52	8 0	8·5388	8 30	8·5383	9 0	8·5375	9 30	8·5369	12 8
11 48	8 1	8·7151	8 31	8·7146	9 1	8·7140	9 31	8·7134	12 12
11 44	8 1	8·8403	8 31	8·8398	9 1	8·8392	9 31	8·8386	12 16
11 40	8 2	8·9377	8 32	8·9372	9 2	8·9366	9 32	8·9360	12 20
11 36	8 3	9·0173	8 33	9·0168	9 3	9·0162	9 33	9·0156	12 24
11 32	8 4	9·0848	8 34	9·0843	9 5	9·0837	9 34	9·0831	12 28
11 28	8 5	9·1435	8 35	9·1430	9 6	9·1423	9 36	9·1417	12 32
11 24	8 6	9·1954	8 36	9·1948	9 7	9·1942	9 37	9·1936	12 36
11 20	8 7	9·2419	8 37	9·2413	9 8	9·2408	9 38	9·2402	12 40
11 16	8 9	9·2843	8 39	9·2837	9 10	9·2831	9 40	9·2825	12 44
11 12	8 11	9·3231	8 41	9·3225	9 12	9·3219	9 42	9·3213	12 48
11 8	8 12	9·3590	8 43	9·3584	9 14	6·3577	9 44	9·3571	12 52
11 4	8 13	9·3923	8 45	9·3917	9 16	9·3911	9 47	9·3905	12 56
11 0	8 15	9·4236	8 48	9·4230	9 19	9·4223	9 50	9·4217	1 0
10 56	8 17	9·4530	8 50	9·4524	9 21	9·4517	9 53	9·4511	1 4
10 52	8 19	9·4809	8 53	9·4803	9 24	9·4795	9 56	9·4788	1 8
10 48	8 21	9·5072	8 56	9·5066	9 27	9·5059	9 59	9·5052	1 12
10 44	8 25	9·5324	8 59	9·5318	9 30	9·5309	10 2	9·5302	1 16
10 40	8 29	9·5565	9 2	9·5559	9 34	9·5551	10 6	9·5544	1 20
10 36	8 33	9·5793	9 6	9·5787	9 38	9·5780	10 10	9·5773	1 24
10 32	8 37	9·6016	9 10	9·6010	9 42	9·6001	10 14	9·5994	1 28
10 28	8 41	9·6230	9 14	9·6224	9 46	9·6215	10 19	9·6208	1 32
10 24	8 45	9·6435	9 18	9·6428	9 51	9·6421	10 24	9·6414	1 36
10 20	8 49	9·6636	9 22	9·6629	9 55	9·6621	10 28	9·6614	1 40
10 16	8 53	9·6830	9 26	9·6823	9 59	9·6815	10 33	9·6807	1 44
10 12	8 58	9·7019	9 31	9·7012	10 5	9·7004	10 38	9·6996	1 48
10 8	9 3	9·7203	9 36	9·7196	10 10	9·7188	10 44	9·7180	1 52
10 4	9 9	9·7384	9 41	9·7377	10 16	9·7368	10 50	9·7360	1 56
10 0	9 15	0·7558	9 47	9·7551	10 22	9·7543	10 57	9·7536	2 0
9 56	9 19	9·7729	9 54	9·7722	10 28	9·7714	11 3	9·7706	2 4
9 52	9 25	9·7898	10 0	9·7891	10 35	9·7883	11 10	9·7874	2 8
9 48	9 31	9·8065	10 6	9·8057	10 41	9·8054	11 17	9·8049	2 12
9 44	9 37	9·8228	10 14	9·8215	10 49	9·8208	11 25	9·8201	2 16
9 40	9 44	9·8389	10 21	9·8381	10 57	9·8372	11 33	9·8361	2 20
9 36	9 51	9·8548	10 28	9·8540	11 5	9·8531	11 41	9·8520	2 24
9 32	9 59	9·8705	10 36	9·8696	11 13	9·8687	11 50	9·8675	2 28
9 28	10 7	9·8860	10 45	9·8851	11 22	9·8842	11 59	9·8829	2 32
9 24	10 15	9·9014	10 53	9·9005	11 31	9·8996	12 9	9·8983	2 36
9 20	10 24	9·9166	11 3	9·9157	11 41	9·9148	12 19	9·9125	2 40
9 16	10 33	9·9318	11 12	9·9309	11 51	9·9299	12 30	9·9275	2 44
9 12	10 43	9·9468	11 23	9·9458	12 2	9·9448	12 41	9·9434	2 48
9 8	10 53	9·9617	11 35	9·9608	12 13	9·9598	12 53	9·9573	2 52
9 4	11 3	9·9766	11 44	9·9751	12 25	9·9735	13 6	9·9720	2 5
9 0	11 14	9·9916	11 54	9·9905	12 36	9·9894	13 19	9·9879	3 0

TABLE III.—DECLINATION.

Apparent Time.	8° 0′		8° 30′		9° 0′		9° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	11 26	10·0065	12 8	10·0054	12 49	10·0042	13 32	10·0028	3 4
8 52	11 39	10·0213	12 22	10·0201	13 4	10·0189	13 47	10·0175	3 8
8 48	11 52	10·0362	12 36	10·0350	13 19	10·0338	14 3	10·0324	3 12
8 44	12 6	10·0511	12 50	10·0498	13 35	10·0485	14 19	10·0470	3 16
8 40	12 20	10·0661	13 5	10·0648	13 51	10·0634	14 36	10·0618	3 20
8 36	12 35	10·0810	13 21	10·0797	14 8	10·0783	14 54	10·0767	3 24
8 32	12 51	10·0962	13 38	10·0948	14 25	10·0931	15 12	10·0914	3 28
8 28	13 8	10·1114	13 56	10·1100	14 44	10·1082	15 32	10·1065	3 32
8 24	13 27	10·1267	14 16	10·1251	15 5	10·1235	15 54	10·1217	3 36
8 20	13 46	10·1421	14 36	10·1405	15 27	10·1389	16 16	10·1370	3 40
8 16	14 6	10·1577	14 58	10·1560	15 50	10·1543	16 33	10·1524	3 44
8 12	14 28	10·1735	15 21	10·1717	16 13	10·1699	17 5	10·1679	3 48
8 8	14 51	10·1894	15 45	10·1875	16 37	10·1856	17 30	10·1835	3 52
8 4	15 16	10·2056	16 11	10·2036	17 5	10·2016	17 59	10·1994	3 56
8 0	15 42	10·2221	16 38	10·2200	17 34	10·2178	18 29	10·2155	4 0
7 56	16 10	10·2387	17 7	10·2365	18 5	10·2341	19 2	10·2317	4 4
7 52	16 41	10·2557	17 43	10·2534	18 38	10·2508	19 36	10·2482	4 8
7 48	17 12	10·2729	18 18	10·2704	19 14	10·2679	20 14	10·2651	4 12
7 44	17 47	10·2905	18 54	10·2878	19 52	10·2852	20 53	10·2822	4 16
7 40	18 24	10·3085	19 31	10·3056	20 33	10·3025	21 36	10·2993	4 20
7 36	19 3	10·3269	20 10	10·3238	21 17	10·3207	22 19	10·3173	4 24
7 32	19 50	10·3457	20 50	10·3424	22 3	10·3393	23 9	10·3357	4 28
7 28	20 37	10·3653	21 48	10·3613	22 54	10·3580	24 2	10·3542	4 32
7 24	21 25	10·3847	22 38	10·3809	23 51	10·3771	25 1	10·3731	4 36
7 20	22 20	10·4045	23 38	10·4004	24 52	10·3964	26 4	10·3921	4 40
7 16	23 20	10·4254	24 41	10·4209	25 58	10·4164	27 12	10·4117	4 44
7 12	24 27	10·4474	25 48	10·4425	27 8	10·4376	28 24	10·4325	4 48
7 8	25 35	10·4687	27 0	10·4638	28 26	10·4593	29 42	10·4538	4 52
7 4	27 0	10·4916	28 22	10·4857	29 54	10·4809	31 12	10·4748	4 56
7 0	28 30	10·5158	29 59	10·5093	31 28	10·5028	32 50	10·4961	5 0
6 56	30 6	10·5386	31 49	10·5315	33 22	10·5242	34 46	10·5169	5 4
6 52	31 58	10·5640	33 41	10·5561	35 10	10·5482	36 37	10·5401	5 8
6 48	34 3	10·5908	35 41	10·5820	37 18	10·5731	38 45	10·5641	5 12
6 44	36 25	10·6163	37 45	10·6066	39 42	10·5984	41 8	10·5884	5 16
6 40	39 0	10·6447	40 25	10·6338	42 21	10·6265	43 51	10·6154	5 20
6 36	41 56	10·6718	43 39	10·6595	45 21	10·6471	46 49	10·6347	5 24
6 32	45 17	10·6996	47 2	10·6857	48 41	10·6719	50 7	10·6582	5 28
6 28	49 4	10·7273	50 48	10·7116	52 25	10·6961	53 48	10·6811	5 32
6 24	53 21	10·7542	55 2	10·7366	56 35	10·7194	57 53	10·7024	5 36
6 20	58 12	10·7798	59 45	10·7602	61 11	10·7412	62 21	10·7225	5 40
6 16	63 36	10·8034	64 59	10·7816	66 14	10·7609	67 15	10·7407	5 44
6 12	69 35	10·8234	70 42	10·7998	71 43	10·7772	72 32	10·7555	5 48
6 8	76 3	10·8389	76 51	10·8147	77 34	10·7897	78 8	10·7663	5 52
6 4	82 55	10·8501	83 20	10·8230	83 43	10·7976	83 56	10·7744	5 56
6 0	90 0	10·8522	90 0	10·8255	90 0	10·8003	90 0	10·7764	6 0

TABLE III.—DECLINATION.

Apparent Time.	10° 0′		10° 30′		11° 0′		11° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	10 0	8·2352	10 30	8·2345	11 0	8·2338	11 30	8·2331	12 4
11 52	10 0	8·5362	10 30	8·5355	11 0	8·5351	11 30	8·5347	12 8
11 48	10 1	8·7127	10 31	8·7120	11 1	8·7113	11 31	8·7106	12 12
11 44	10 1	8·8379	10 31	8·8372	11 1	8·8365	11 32	8·8358	12 16
11 40	10 2	8·9353	10 32	8·9346	11 2	8·9339	11 33	8·9332	12 20
11 36	10 3	9·0149	10 33	9·0142	11 3	9·0135	11 34	9·0128	12 24
11 32	10 4	9·0824	10 34	9·0817	11 4	9·0810	11 35	9·0803	12 28
11 28	10 6	9·1410	10 36	9·1403	11 6	9·1396	11 36	9·1389	12 32
11 24	10 7	9·1929	10 38	9·1922	11 8	9·1915	11 38	9·1908	12 36
11 20	10 8	9·2395	10 40	9·2388	11 10	9·2381	11 40	9·2374	12 40
11 16	10 10	9·2818	10 42	9·2811	11 12	9·2804	11 42	9·2796	12 44
11 12	10 12	9·3206	10 44	9·3199	11 14	9·3192	11 45	9·3184	12 48
11 8	10 15	9·3564	10 47	9·3557	11 17	9·3550	11 48	9·3542	12 52
11 4	10 18	9·3898	10 50	9·3891	11 20	9·3884	11 51	9·3876	12 56
11 0	10 22	9·4210	10 53	9·4203	11 23	9·4195	11 55	9·4187	1 0
10 56	10 24	9·4504	10 56	9·4496	11 26	9·4488	11 58	9·4480	1 4
10 52	10 27	9·4781	10 59	9·4773	11 29	9·4765	12 1	9·4757	1 8
10 48	10 30	9·5045	11 2	9·5037	11 33	9·5029	12 4	9·5021	1 12
10 44	10 33	9·5294	11 6	9·5286	11 37	9·5278	12 8	9·5270	1 16
10 40	10 36	9·5536	11 10	9·5528	11 42	9·5520	12 12	9·5512	1 20
10 36	10 39	9·5765	11 14	9·5757	11 47	9·5749	12 17	9·5740	1 24
10 32	10 44	9·5986	11 19	9·5978	11 51	9·5970	12 22	9·5961	1 28
10 28	10 50	9·6200	11 24	9·6191	11 56	9·6182	12 27	9·6173	1 32
10 24	10 56	9·6406	11 29	9·6397	12 1	9·6388	12 33	9·6379	1 36
10 20	11 1	9·6606	11 34	9·6597	12 6	9·6588	12 39	9·6579	1 40
10 16	11 6	9·6798	11 39	9·6789	12 12	9·6780	12 45	9·6770	1 44
10 12	11 12	9·6987	11 45	9·6978	12 18	9·6969	12 52	9·6960	1 48
10 8	11 18	9·7170	11 51	9·7160	12 25	9·7150	12 59	9·7140	1 52
10 4	11 24	9·7350	11 58	9·7340	12 32	9·7330	13 6	9·7320	1 56
10 0	11 31	9·7526	12 5	9·7516	12 39	9·7506	13 13	9·7496	2 0
9 56	11 37	9·7697	12 12	9·7687	12 46	9·7678	13 21	9·7668	2 4
9 52	11 44	9·7865	12 20	9·7855	12 54	9·7844	13 29	9·7835	2 8
9 48	11 52	9·8040	12 28	9·8030	13 3	9·8021	13 38	9·8011	2 12
9 44	12 1	9·8192	12 36	9·8182	13 12	9·8173	13 47	9·8163	2 16
9 40	12 9	9·8351	12 45	9·8341	13 21	9·8331	13 57	9·8320	2 20
9 36	12 18	9·8510	12 54	9·8499	13 31	9·8489	14 7	9·8478	2 24
9 32	12 27	9·8665	13 4	9·8654	13 41	9·8643	14 18	9·8632	2 28
9 28	12 37	9·8819	13 14	9·8808	13 52	9·8797	14 29	9·8786	2 32
9 24	12 47	9·8972	13 25	9·8961	14 3	9·8850	14 40	9·8738	2 36
9 20	12 58	9·9116	13 36	9·9107	14 14	9·9098	14 52	9·9088	2 40
9 16	13 9	9·9266	13 48	9·9256	14 27	9·9246	15 5	9·9236	2 44
9 12	13 21	9·9422	14 0	9·9409	14 40	9·9397	15 18	9·9384	2 48
9 8	13 33	9·9567	14 12	9·9563	14 53	9·9558	15 33	9·9552	2 52
9 4	13 46	9·9707	14 27	9·9694	15 7	9·9681	15 47	9·9667	2 56
9 0	13 59	9·9871	14 41	9·9852	15 22	9·9888	16 3	9·9824	3 0

TABLE III.—DECLINATION.

Apparent Time.	10° 0′		10° 30′		11° 0′		11° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	14 14	10·0014	14 57	10·0000	15 39	9·9985	16 20	9·9970	3 4
8 52	14 30	10·0161	15 12	10·0146	15 56	10·0131	16 38	10·0116	3 8
8 48	14 46	10·0310	15 30	10·0295	16 13	10·0280	16 55	10·0264	3 12
8 44	15 3	10·0455	15 47	10·0440	16 31	10·0424	17 14	10·0408	3 16
8 40	15 21	10·0603	16 6	10·0587	16 50	10·0570	17 34	10·0553	3 20
8 36	15 39	10·0751	16 25	10·0735	17 10	10·0718	17 55	10·0700	3 24
8 32	15 58	10·0897	16 45	10·0880	17 31	10·0862	18 18	10·0843	3 28
8 28	16 19	10·1047	17 7	10·1030	17 54	10·1012	18 41	10·0992	3 32
8 24	16 42	10·1199	17 30	10·1181	18 18	10·1162	19 6	10·1140	3 36
8 20	17 5	10·1351	17 54	10·1332	18 43	10·1312	19 32	10·1290	3 40
8 16	17 29	10·1504	18 18	10·1484	19 10	10·1463	20 0	10·1440	3 44
8 12	17 56	10·1658	18 46	10·1637	19 39	10·1615	20 29	10·1591	3 48
8 8	18 23	10·1813	19 16	10·1791	20 9	10·1768	21 0	10·1743	3 52
8 4	18 53	10·1971	19 47	10·1948	20 40	10·1924	21 33	10·1898	3 56
8 0	19 24	10·2131	20 19	10·2106	21 14	10·2080	22 8	10·2053	4 0
7 56	19 58	10·2292	20 54	10·2266	21 50	10·2239	22 46	10·2211	4 4
7 52	20 33	10·2455	21 31	10·2427	22 28	10·2399	23 26	10·2369	4 8
7 48	21 13	10·2622	22 12	10·2592	23 11	10·2562	24 9	10·2530	4 12
7 44	21 54	10·2791	22 55	10·2760	23 56	10·2728	24 53	10·2694	4 16
7 40	22 38	10·2960	23 41	10·2927	24 43	10·2893	25 41	10·2857	4 20
7 36	23 20	10·3138	24 27	10·3103	25 33	10·3067	26 35	10·3029	4 24
7 32	24 15	10·3320	25 21	10·3283	26 27	10·3242	27 31	10·3201	4 28
7 28	25 10	10·3503	26 18	10·3463	27 26	10·3419	28 31	10·3375	4 32
7 24	26 10	10·3689	27 20	10·3645	28 29	10·3598	29 35	10·3551	4 36
7 20	27 16	10·3876	28 28	10·3829	29 39	10·3808	30 45	10·3758	4 40
7 16	28 25	10·4068	29 39	10·4017	30 52	10·3988	31 59	10·3934	4 44
7 12	29 39	10·4271	30 55	10·4216	32 10	10·4158	33 21	10·4111	4 48
7 8	30 58	10·4479	32 16	10·4419	33 30	10·4356	34 45	10·4293	4 52
7 4	32 26	10·4684	33 55	10·4619	35 5	10·4551	36 23	10·4483	4 56
7 0	34 12	10·4892	35 36	10·4821	36 55	10·4748	38 10	10·4674	5 0
6 56	36 9	10·5094	37 27	10·5016	38 55	10·4936	40 5	10·4856	5 4
6 52	38 5	10·5318	39 29	10·5233	40 55	10·5146	42 5	10·5059	5 8
6 48	40 12	10·5549	41 39	10·5456	43 5	10·5362	44 22	10·5268	5 12
6 44	42 34	10·5782	44 0	10·5680	45 25	10·5578	46 47	10·5476	5 16
6 40	45 19	10·6041	46 47	10·5929	48 15	10·5818	49 32	10·5707	5 20
6 36	48 16	10·6223	49 44	10·6099	51 11	10·5975	52 25	10·5853	5 24
6 32	51 33	10·6445	52 59	10·6309	54 24	10·6163	55 36	10·6031	5 28
6 28	55 10	10·6661	56 33	10·6511	57 55	10·6361	59 3	10·6219	5 32
6 24	59 10	10·6857	60 39	10·6697	61 44	10·6537	62 47	10·6384	5 36
6 20	63 31	10·7040	64 41	10·6865	65 51	10·6695	66 47	10·6531	5 40
6 16	68 15	10·7211	69 16	10·7022	70 16	10·6840	71 4	10·6661	5 44
6 12	73 20	10·7355	74 8	10·7171	74 56	10·6904	75 34	10·6768	5 48
6 8	78 42	10·7443	79 16	10·7236	79 49	10·7042	80 15	10·6854	5 52
6 4	84 18	10·7520	84 35	10·7304	84 52	10·7096	85 5	10·6904	5 56
6 0	90 0	10·7537	90 0	10·7320	90 0	10·7113	90 0	10·6915	6 0

TABLE III.—DECLINATION.

Apparent Time.	12° 0′		12° 30′		13° 0′		13° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	12 0	8·2323	12 30	8·2315	13 0	8·2307	13 30	8·2299	12 4
11 52	12 0	8·5335	12 30	8·5327	13 0	8·5319	13 30	8·5311	12 8
11 48	12 1	8·7098	12 31	8·7090	13 1	8·7082	13 31	8·7074	12 12
11 44	12 2	8·8350	12 32	8·8342	13 2	8·8334	13 32	8·8326	12 16
11 40	12 3	8·9324	12 33	8·9316	13 3	8·9308	13 33	8·9300	12 20
11 36	12 4	9·0119	12 34	9·0111	13 4	9·0103	13 34	9·0095	12 24
11 32	12 5	9·0784	12 35	9·0776	13 6	9·0768	13 36	9·0760	12 28
11 28	12 7	9·1380	12 37	9·1372	13 8	9·2364	13 38	9·1355	12 32
11 24	12 9	9·1899	12 39	9·1891	13 10	9·1883	13 40	9·1874	12 26
11 20	12 11	9·2364	12 41	9·2356	13 12	9·2348	13 42	9·2339	12 40
11 16	12 13	9·2788	12 43	9·2779	13 14	9·2771	13 44	9·2762	12 44
11 12	12 15	9·3175	12 46	9·3166	13 17	9·3158	13 47	9·3149	12 48
11 8	12 18	9·3533	12 49	9·3524	13 20	9·3516	13 50	9·3507	12 52
11 4	12 21	9·3866	12 52	9·3857	13 23	9·3848	13 54	9·3839	12 56
11 0	12 25	9·4178	12 56	9·4169	13 27	9·4160	13 58	9·4151	1 0
10 56	12 28	9·4471	12 59	9·4462	13 31	9·4453	14 2	9·4444	1 4
10 52	12 32	9·4749	13 3	9·4740	13 35	9·4731	14 6	9·4720	1 8
10 48	12 36	9·5012	13 7	9·5003	13 39	9·4994	14 10	9·4984	1 12
10 44	12 40	9·5263	13 12	9·5254	13 43	9·5245	14 15	9·5235	1 16
10 40	12 44	9·5503	13 17	9·5494	13 48	9·5485	14 20	9·5475	1 20
10 36	12 49	9·5732	13 22	9·5723	13 53	9·5714	14 26	9·5704	1 24
10 32	12 54	9·5953	13 27	9·5944	13 59	9·5935	14 32	9·5925	1 28
10 28	13 0	9·6167	13 33	9·6158	14 5	9·6148	14 38	9·6137	1 32
10 24	13 6	9·6371	13 39	9·6362	14 11	9·6352	14 44	9·6341	1 36
10 20	13 12	9·6571	13 45	9·6562	14 15	9·6551	14 51	9·6541	1 40
10 16	13 18	9·6764	13 51	9·6754	14 21	9·6743	14 58	9·6732	1 44
10 12	13 25	9·6952	13 58	9·6942	14 37	9·6931	15 5	9·6920	1 48
10 8	13 32	9·7135	14 6	9·7125	14 43	9·7114	15 13	9·7102	1 52
10 4	13 39	9·7314	14 14	9·7304	14 49	9·7293	15 21	9·7281	1 56
10 0	13 47	9·7487	14 22	9·7476	14 56	9·7465	15 30	9·7453	2 0
9 56	13 55	9·7658	14 30	9·7647	15 5	9·7636	15 39	9·7624	2 4
9 52	14 4	9·7826	14 39	9·7815	15 14	9·7803	15 48	9·7791	2 8
9 48	14 13	9·7990	14 48	9·7978	15 23	9·7966	15 58	9·7954	2 12
9 44	14 23	9·8152	14 58	9·8140	15 33	9·8128	16 9	9·8116	2 16
9 40	14 33	9·8311	15 9	9·8299	15 44	9·8286	16 20	9·8273	2 20
9 36	14 43	9·8468	15 20	9·8456	15 55	9·8443	16 31	9·8430	2 24
9 32	14 54	9·8622	15 31	9·8610	16 7	9·8597	16 44	9·8583	2 28
9 28	15 6	9·8775	15 43	9·8762	16 20	9·8748	16 57	9·8734	2 32
9 24	15 18	9·8927	15 55	9·8914	16 33	9·8900	17 10	9·8886	2 36
9 20	14 31	9·9077	16 8	9·9064	16 47	9·9050	17 24	9·9036	2 40
9 16	15 44	9·9226	16 22	9·9212	17 1	9·9197	17 39	9·9181	2 44
9 12	15 57	9·9373	16 36	9·9360	17 15	9·9345	17 54	9·9330	2 48
9 8	16 12	9·9521	16 52	9·9507	17 31	9·9491	18 11	9·9476	2 52
9 4	16 28	9·9666	17 8	9·9651	17 47	9·9635	18 28	9·9618	2 56
9 0	16 44	9·9812	17 24	9·9796	18 5	9·9780	18 45	9·9763	3 0

TABLE III.—DECLINATION.

Apparent Time.	12° 0′		12° 30′		13° 0′		13° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	17 1	9·9958	17 42	9·9940	18 22	9·9922	19 4	9·9904	2 4
8 52	17 19	10·0102	18 1	10·0084	18 42	10·0065	19 24	10·0046	3 8
8 48	17 37	10·0247	18 20	10·0229	19 2	10·0211	19 44	10·0193	3 12
8 44	17 57	10·0391	18 40	10·0372	19 23	10·0354	20 6	10·0335	3 16
8 40	18 18	10·0536	19 2	10·0517	19 45	10·0498	20 29	10·0478	3 20
8 36	18 40	10·0681	19 25	10·0661	20 9	10·0641	20 53	10·0620	3 24
8 32	19 4	10·0827	19 49	10·0807	20 34	10·0787	21 19	10·0766	3 28
8 28	19 28	10·0973	20 14	10·0952	20 59	10·0931	21 45	10·0908	3 32
8 24	19 53	10·1120	20 40	10·1098	21 26	10·1076	22 13	10·1053	3 36
8 20	20 20	10·1269	21 8	10·1247	21 55	10·1224	22 42	10·1200	3 40
8 16	20 49	10·1417	21 37	10·1394	22 25	10·1370	23 13	10·1345	3 44
8 12	21 19	10·1567	22 9	10·1543	22 58	10·1517	23 47	10·1490	3 48
8 8	21 50	10·1718	22 41	10·1693	23 31	10·1666	24 22	10·1638	3 52
8 4	22 25	10·1870	23 17	10·1844	24 8	10·1816	24 59	10·1785	3 56
8 0	23 2	10·2025	23 54	10·1998	24 46	10·1968	25 38	10·1936	4 0
7 56	23 41	10·2180	24 34	10·2151	25 27	10·2120	26 20	10·2087	4 4
7 52	24 23	10·2338	25 17	10·2507	26 10	10·2274	27 4	10·2238	4 8
7 48	25 6	10·2498	26 2	10·2464	26 57	10·2429	27 52	10·2392	4 12
7 44	25 49	10·2660	26 47	10·2623	27 44	10·2586	28 41	10·2548	4 16
7 40	26 39	10·2824	27 38	10·2784	28 36	10·2745	29 34	10·2705	4 20
7 36	27 36	10·2990	28 35	10·2947	29 34	10·2905	30 33	10·2863	4 24
7 32	28 34	10·3155	29 34	10·3112	30 34	10·3068	31 34	10·3023	4 28
7 28	29 36	10·3326	30 37	10·3280	32 38	10·3233	32 39	10·3189	4 32
7 24	30 41	10·3503	31 44	10·3454	32 46	10·3404	33 48	10·3352	4 36
7 20	31 50	10·3684	32 54	10·3632	33 58	10·3578	35 2	10·3523	4 40
7 16	33 5	10·3870	34 11	10·3814	35 16	10·3757	36 21	10·3699	4 44
7 12	34 31	10·4041	35 37	10·3981	36 43	10·3920	37 49	10·3858	4 48
7 8	36 0	10·4216	37 7	10·4151	38 14	10·4085	39 21	10·4018	4 52
7 4	37 40	10·4399	38 48	10·4329	39 56	10·4258	41 4	10·4186	4 56
7 0	39 24	10·4600	40 32	10·4524	41 40	10·4447	42 48	10·4370	5 0
6 56	41 14	10·4783	42 23	10·4701	43 32	10·4618	44 41	10·4535	5 4
6 52	43 14	10·4968	44 25	10·4880	45 36	10·4791	46 47	10·4702	5 8
6 48	45 38	10·5172	46 46	10·5077	47 54	10·4981	49 2	10·4885	5 12
6 44	48 8	10·5400	49 15	10·5297	50 22	10·5193	51 29	10·5089	5 16
6 40	50 48	10·5573	51 54	10·5461	52 59	10·5349	54 5	10·5238	5 20
6 36	53 39	10·5731	54 43	10·5610	55 47	10·5491	56 51	10·5373	5 24
6 32	56 47	10·5908	57 48	10·5778	58 49	10·5650	59 50	10·5525	5 28
6 28	60 10	10·6076	61 7	10·5935	62 4	10·5795	63 1	10·5657	5 32
6 24	63 49	10·6231	64 41	10·6001	65 32	10·5936	66 24	10·5794	5 36
6 20	67 42	10·6371	68 28	10·6212	69 13	10·6057	69 59	10·5909	5 40
6 16	71 52	10·6485	72 30	10·6321	73 7	10·6161	73 45	10·6008	5 44
6 12	76 12	10·6582	76 42	10·6412	77 11	10·6246	77 40	10·6087	5 48
6 8	80 41	10·6665	81 22	10·6488	81 22	10·6315	81 42	10·6149	5 52
6 4	85 18	10·6712	85 29	10·6531	85 39	10·6354	85 50	10·6184	5 56
6 0	90 0	10·6725	90 0	10·6542	94 0	10·6366	90 0	10·6196	6 0

TABLE III.—DECLINATION.

Apparent Time.	14° 0′		14° 30′		15° 0′		15° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	14 0	8·2290	14 30	8·2282	15 0	8·2268	15 30	8·2258	12 4
11 52	14 0	8·5302	14 30	8·5293	15 0	8·4280	15 30	8·4270	12 8
11 48	14 1	8·7065	14 31	8·7056	15 1	8·7043	15 31	8·7033	12 12
11 44	14 2	8·8317	14 32	8·8308	15 2	8·8294	15 32	8·8284	12 16
11 40	14 3	8·9291	14 33	8·9282	15 3	8·9268	15 33	8·9258	12 20
11 36	14 4	9·0086	14 35	9·0077	15 5	9·0064	15 35	9·0054	12 24
11 32	14 6	9·0751	14 36	9·0742	15 7	9·0739	15 37	9·0729	12 28
11 28	14 8	9·1346	14 38	9·1337	15 9	9·1325	15 39	9·1315	12 32
11 24	14 10	9·1865	14 40	9·1856	15 11	9·1843	15 41	9·1832	12 36
11 20	14 12	9·2330	14 42	9·2321	15 13	9·2308	15 44	9·2297	12 40
11 16	14 15	9·2753	14 45	9·2744	15 16	9·2731	15 47	9·2720	12 44
11 12	14 18	9·3140	14 48	9·3131	15 19	9·3118	15 50	9·3107	12 48
11 8	14 21	9·3498	14 52	9·3489	15 22	9·3476	15 53	9·3465	12 52
11 4	14 24	9·3830	14 56	9·3820	15 26	9·3809	15 57	9·3798	12 56
11 0	14 28	9·4142	15 0	9·4132	15 30	9·4120	16 1	9·4109	1 0
10 56	14 32	9·4435	15 4	9·4425	15 34	9·4413	16 5	9·4402	1 4
10 52	14 36	9·4710	15 8	9·4700	15 39	9·4689	16 10	9·4669	1 8
10 48	14 41	9·4974	15 13	9·4964	15 44	9·4952	16 15	9·4941	1 12
10 44	14 46	9·5225	15 18	9·5215	15 49	9·5202	16 20	9·5191	1 16
10 40	14 51	9·5464	15 23	9·5453	15 55	9·5441	16 26	9·5430	1 20
10 36	14 57	9·5693	15 29	9·5682	16 1	9·5670	16 32	9·5658	1 24
10 32	15 3	9·5914	15 35	9·5903	16 7	9·5889	16 39	9·5877	1 28
10 28	15 9	9·6126	15 41	9·6115	16 14	9·6102	16 46	9·6090	1 32
10 24	15 16	9·6330	15 48	9·6318	16 21	9·6307	16 53	9·6285	1 36
10 20	15 23	9·6530	15 55	9·6518	16 28	9·6505	17 1	9·6493	1 40
10 16	15 30	9·6720	16 3	9·6708	16 36	9·6697	17 9	9·6685	1 44
10 12	15 38	9·6908	16 11	9·6896	16 44	9·6884	17 17	9·6871	1 48
10 8	15 46	9·7090	16 20	9·7078	16 53	9·7066	17 26	9·7053	1 52
10 4	15 55	9·7269	16 29	9·7256	17 2	9·7244	17 35	9·7231	1 56
10 0	16 4	9·7441	16 38	9·7428	17 11	9·7416	17 45	9·7402	2 0
9 56	16 13	9·7612	16 48	9·7599	17 21	9·7585	17 56	9·7571	2 4
9 52	16 23	9·7778	16 58	9·7764	17 32	9·7751	18 7	9·7737	2 8
9 48	16 33	9·7941	17 8	9·7927	17 43	9·7914	18 18	9·7900	2 12
9 44	16 44	9·8103	17 19	9·8089	17 55	9·8074	18 30	9·8060	2 16
9 40	16 55	9·8260	17 30	9·8246	18 7	9·8231	18 42	9·8216	2 20
9 36	17 7	9·8416	17 42	9·8402	18 19	9·8387	18 55	9·8372	2 24
9 32	17 20	9·8569	17 56	9·8555	18 33	9·8539	19 9	9·8524	2 28
9 28	17 33	9·8720	18 10	9·8706	18 47	9·8690	19 23	9·8674	2 32
9 24	17 47	9·8871	18 24	9·8856	19 2	9·8840	19 38	9·8824	2 36
9 20	18 2	9·9021	18 39	9·9005	19 18	9·8987	19 54	9·8971	2 40
9 16	18 17	9·9166	18 55	9·9150	19 34	9·9134	20 11	9·9117	2 44
9 12	18 33	9·9314	19 11	9·9297	19 50	9·9279	20 28	9·9261	2 48
9 8	18 50	9·9460	19 29	9·9443	20 8	9·9424	20 47	9·9406	2 52
9 4	19 7	9·9602	19 47	9·9585	20 26	9·9666	21 6	9·9647	2 56
9 0	19 25	9·9746	20 6	9·9728	20 45	9·9709	21 25	9·9689	3 0

TABLE III.—DECLINATION.

Apparent Time.	14° 0′		14° 30′		15° 0′		15° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	19 45	9·9884	20 26	9·9863	21 6	9·9851	21 46	9·9831	3 4
8 52	20 5	10·0029	20 47	10·0010	21 28	9·9992	22 9	9·9971	3 8
8 48	20 26	10·0174	21 8	10·0154	21 50	10·0133	22 31	10·0112	3 12
8 44	20 48	10·0315	21 30	10·0295	22 13	10·0273	22 55	10·0251	3 16
8 40	21 12	10·0458	21 55	10·0436	22 38	10·0414	23 20	10·0392	3 20
8 36	21 37	10·0599	22 21	10·0577	23 4	10·0554	23 47	10·0531	3 24
8 32	22 3	10·0744	22 48	10·0721	23 31	10·0693	24 15	10·0669	3 28
8 28	22 30	10·0885	23 16	10·0861	24 0	10·0835	24 45	10·0810	3 32
8 24	22 59	10·1029	23 45	10·1004	24 31	10·0977	25 16	10·0951	3 36
8 20	23 29	10·1175	24 16	10·1149	25 3	10·1119	25 38	10·1092	3 40
8 16	24 1	10·1318	24 49	10·1291	25 37	10·1261	26 23	10·1233	3 44
8 12	24 36	10·1462	25 24	10·1433	26 12	10·1404	26 59	10·1374	3 48
8 8	25 12	10·1606	26 0	10·1576	26 49	10·1546	27 37	10·1515	3 52
8 4	25 50	10·1755	26 39	10·1723	27 28	10·1691	28 17	10·1658	3 56
8 0	26 30	10·1904	27 21	10·1871	28 11	10·1838	29 0	10·1804	4 0
7 56	27 13	10·2054	28 5	10·2020	28 54	10·1984	29 44	10·1948	4 4
7 52	27 57	10·2202	28 53	10·2166	29 43	10·2131	30 33	10·2094	4 8
7 48	28 47	10·2355	29 40	10·2317	30 33	10·2279	31 24	10·2240	4 12
7 44	29 38	10·2509	30 32	10·2469	31 26	10·2420	32 19	10·2388	4 16
7 40	30 32	10·2663	31 26	10·2620	32 22	10·2581	33 16	10·2536	4 20
7 36	31 31	10·2820	32 27	10·2775	33 23	10·2731	34 17	10·2684	4 24
7 32	32 34	10·2977	33 31	10·2930	34 28	10·2881	35 22	10·2832	4 28
7 28	33 40	10·3138	34 38	10·3089	35 36	10·3036	36 32	10·2985	4 32
7 24	34 50	10·3300	35 49	10·3248	36 47	10·3194	37 43	10·3140	4 36
7 20	36 5	10·3465	37 6	10·3410	38 7	10·3355	39 2	10·3298	4 40
7 16	37 26	10·3632	38 28	10·3572	39 30	10·3510	40 25	10·3449	4 44
7 12	38 54	10·3794	39 55	10·3730	40 56	10·3665	41 53	10·3600	4 48
7 8	40 28	10·3953	41 35	10·3895	42 27	10·3828	43 29	10·3759	4 52
7 4	42 8	10·4120	43 11	10·4053	44 6	10·3985	45 10	10·3912	4 56
7 0	43 56	10·4293	44 58	10·4215	46 0	10·4137	46 57	10·4059	5 0
6 56	45 50	10·4456	46 57	10·4374	48 3	10·4292	48 58	10·4209	5 4
6 52	47 58	10·4620	49 3	10·4542	50 7	10·4446	51 2	10·4358	5 8
6 48	50 10	10·4790	51 11	10·4695	52 12	10·4600	53 6	10·4506	5 12
6 44	52 36	10·4963	53 38	10·4863	54 40	10·4768	55 30	10·4668	5 16
6 40	55 10	10·5111	56 10	10·4985	57 10	10·4892	57 58	10·4786	5 20
6 36	57 54	10·5257	58 49	10·5142	59 44	10·5028	60 32	10·4915	5 24
6 32	60 50	10·5401	61 42	10·5280	62 33	10·5158	63 18	10·5039	5 28
6 28	63 57	10·5535	64 45	10·5407	65 32	10·5279	66 13	10·5154	5 32
6 24	67 15	10·5656	67 59	10·5522	68 42	10·5398	69 19	10·5266	5 36
6 20	70 44	10·5765	71 23	10·5625	72 1	10·5484	72 32	10·5348	5 40
6 16	74 22	10·5859	74 54	10·5714	75 26	10·5559	75 52	10·5423	5 44
6 12	78 9	10·5932	78 33	10·5782	78 57	10·5631	79 17	10·5486	5 48
6 8	82 2	10·5987	82 19	10·5834	82 35	10·5681	82 49	10·5532	5 52
6 4	86 0	10·6021	86 8	10·5865	86 16	10·5709	86 23	10·5556	5 56
6 0	90 0	10·6032	90 0	10·5873	90 0	10·5719	90 0	10·5570	6 0

TABLE III.—DECLINATION.

Apparent Time.	16° 0′		16° 30′		17° 0′		17° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	16 0	8·2247	16 30	8·2236	17 0	8·2225	17 30	8·2213	12 4
11 52	16 0	8·4259	16 30	8·5248	17 0	8·4237	17 30	8·4225	12 8
11 48	16 1	8·7022	16 31	8·7011	17 1	8·7000	17 31	8·6988	12 12
11 44	16 2	8·8273	16 32	8·8262	17 2	8·8251	17 32	8·8239	12 16
11 40	16 3	8·9247	16 33	8·9236	17 3	8·9225	17 33	8·9213	12 20
11 36	16 5	9·0043	16 35	9·0032	17 5	9·0020	17 35	9·0008	12 24
11 32	16 7	9·0718	16 37	9·0707	17 7	9·0695	17 37	9·0673	12 28
11 28	16 9	9·1304	16 39	9·1293	17 9	9·1281	17 39	9·1269	12 32
11 24	16 12	9·1821	16 42	9·1810	17 12	9·1798	17 42	9·1786	12 36
11 20	16 14	9·2286	16 45	9·2275	17 15	9·2263	17 45	9·2251	12 40
11 16	16 17	9·2709	16 48	9·2698	17 18	9·2686	17 48	9·2674	12 44
11 12	16 20	9·3096	16 51	9·3085	17 21	9·3073	17 52	9·3060	12 48
11 8	16 24	9·3454	16 55	9·3443	17 25	9·3431	17 56	9·3418	12 52
11 4	16 28	9·3787	16 59	9·3776	17 29	9·3764	18 0	9·3751	12 56
11 0	16 32	9·4098	17 3	9·4086	17 34	9·4074	18 4	9·4061	1 0
10 56	16 37	9·4391	17 8	9·4379	17 39	9·4367	18 9	9·4354	1 4
10 52	16 42	9·4657	17 13	9·4645	17 44	9·4633	18 14	9·4620	1 8
10 48	16 47	9·4929	17 18	9·4917	17 49	9·4905	18 20	9·4892	1 1
10 44	16 53	9·5179	17 23	9·5167	17 55	9·5155	18 26	9·5142	1 16
10 40	16 59	9·5418	17 29	9·5406	18 1	9·5393	18 32	9·5380	1 20
10 36	17 5	9·5646	17 36	9·5634	18 8	9·5621	18 39	9·5608	1 24
10 32	17 12	9·5865	17 43	9·5853	18 15	9·5840	18 47	9·5827	1 28
10 28	17 19	9·6078	17 51	9·6066	18 22	9·6053	18 55	9·6039	1 32
10 24	17 26	9·6272	17 58	9·6259	18 30	9·6246	19 3	9·6232	1 36
10 20	17 34	9·6480	18 6	9·6467	18 38	9·6454	19 11	9·6440	1 40
10 16	17 42	9·6672	18 14	9·6659	18 47	9·6646	19 20	9·6632	1 44
10 12	17 50	9·6858	18 23	9·6844	18 56	9·6830	19 29	9·6815	1 48
10 8	17 59	9·7040	18 33	9·7026	19 6	9·7012	19 39	9·6997	1 52
10 4	18 9	9·7218	18 43	9·7204	19 16	9·7190	19 49	9·7174	1 56
10 0	18 19	9·7388	18 53	9·7374	19 26	9·7359	20 0	9·7343	2 0
9 56	18 30	9·7557	19 4	9·7542	19 38	9·7527	20 12	9·7511	2 4
9 52	18 41	9·7723	19 16	9·7708	19 50	9·7693	20 24	9·7677	2 8
9 48	18 53	9·7885	19 28	9·7870	20 3	9·7854	20 37	9·7837	2 12
9 44	19 5	9·8045	19 40	9·8030	20 16	9·8014	20 50	9·7997	2 16
9 40	19 18	9·8201	19 53	9·8186	20 29	9·8170	21 3	9·8153	2 20
9 36	19 31	9·8356	20 6	9·8340	20 42	9·8323	21 17	9·8305	2 24
9 32	19 45	9·8508	20 21	9·8491	20 57	9·8474	21 33	9·8456	2 28
9 28	20 0	9·8658	20 36	9·8641	21 12	9·8623	21 49	9·8605	2 32
9 24	20 15	9·8807	20 52	9·8790	21 28	9·8772	22 5	9·8753	2 36
9 20	20 32	9·8953	21 19	9·8934	21 45	9·8916	22 23	9·8897	2 40
9 16	20 59	9·9100	21 26	9·9082	22 3	9·9064	22 41	9·9045	2 44
9 12	21 6	9·9243	21 44	9·9224	22 21	9·9205	22 59	9·9185	2 48
9 8	21 25	9·9388	22 4	9·9369	22 41	9·9349	23 19	9·9329	2 52
9 4	21 44	9·9628	22 24	9·9608	23 2	9·9588	23 40	9·9567	2 56
9 0	22 4	9·9669	22 44	9·9649	23 23	9·9628	24 2	9·9606	3 0

TABLE III.—DECLINATION.

Apparent Time.	16° 0′		16° 30′		17° 0′		17° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	22 26	9·9811	23 6	9·9790	23 46	9·9769	24 26	9·9746	3 4
8 52	22 49	9·9950	23 29	9·9928	24 9	9·9906	24 49	9·9882	3 8
8 48	23 12	10·0090	23 53	10·0067	24 33	10·0044	25 14	10·0020	3 12
8 44	23 36	10·0229	24 17	10·0206	24 58	10·0182	25 40	10·0157	3 16
8 40	24 1	10·0369	24 43	10·0345	25 24	10·0320	26 7	10·0294	3 20
8 36	24 29	10·0507	25 12	10·0482	25 54	10·0456	26 36	10·0430	3 24
8 32	24 58	10·0644	25 42	10·0618	26 25	10·0591	27 7	10·0564	3 28
8 28	25 29	10·0784	26 13	10·0757	26 57	10·0729	27 40	10·0701	3 32
8 24	26 0	10·0924	26 45	10·0896	27 29	10·0867	28 13	10·0838	3 36
8 20	26 33	10·1064	27 18	10·1035	28 3	10·1005	28 48	10·0975	3 40
8 16	27 8	10·1204	27 54	10·1174	28 39	10·1143	29 25	10·1112	3 44
8 12	27 45	10·1343	28 32	10·1312	29 18	10·1280	30 4	10·1247	3 48
8 8	28 24	10·1483	29 12	10·1451	29 59	10·1418	30 45	10·1384	3 52
8 4	29 5	10·1624	29 54	10·1589	30 42	10·1554	31 49	10·1518	3 56
8 0	29 49	10·1769	30 38	10·1733	31 26	10·1696	32 14	10·1658	4 0
7 56	30 34	10·1911	31 24	10·1874	32 13	10·1835	33 2	10·1796	4 4
7 52	31 23	10·2055	32 13	10·2016	33 3	10·1976	33 53	10·1935	4 8
7 48	32 15	10·2199	33 6	10·2158	33 57	10·2116	34 47	10·2073	4 12
7 44	33 11	10·2345	34 3	10·2302	34 55	10·2258	35 45	10·2213	4 16
7 40	34 9	10·2491	35 2	10·2445	35 55	10·2399	36 46	10·2352	4 20
7 36	35 10	10·2637	36 3	10·2589	36 56	10·2541	37 47	10·2492	4 24
7 32	36 16	10·2783	37 10	10·2732	38 3	10·2681	38 53	10·2629	4 28
7 28	37 27	10·2933	38 23	10·2880	39 18	10·2826	40 7	10·2771	4 32
7 24	38 38	10·3085	39 33	10·3028	40 28	10·2974	41 20	10·2916	4 36
7 20	39 56	10·3240	40 51	10·3180	41 45	10·3122	42 39	10·3061	4 40
7 16	41 20	10·3387	42 15	10·3324	43 10	10·3266	44 4	10·3202	4 44
7 12	42 49	10·3534	43 45	10·3467	44 41	10·3400	45 34	10·3333	4 48
7 8	44 27	10·3689	45 23	10·3618	46 10	10·3547	47 0	10·3476	4 52
7 4	46 8	10·3838	47 4	10·3763	47 40	10·3688	48 41	10·3613	4 56
7 0	47 53	10·3980	48 49	10·3901	49 45	10·3822	50 36	10·3743	5 0
6 56	49 52	10·4115	50 47	10·4031	51 41	10·3947	52 31	10·3863	5 4
6 52	51 56	10·4269	52 51	10·4180	53 45	10·4091	54 34	10·4003	5 8
6 48	54 0	10·4412	54 54	10·4318	55 47	10·4225	56 34	10·4133	5 12
6 44	56 19	10·4568	57 9	10·4468	57 58	10·4369	58 46	10·4272	5 16
6 40	58 45	10·4680	59 33	10·4575	60 20	10·4471	61 7	10·4370	5 20
6 36	61 19	10·4803	62 7	10·4693	62 54	10·4584	63 36	10·4478	5 24
6 32	64 2	10·4922	64 47	10·4807	65 31	10·4695	66 10	10·4584	5 28
6 28	66 54	10·5032	67 35	10·4912	68 16	10·4800	68 51	10·4686	5 32
6 24	69 55	10·5139	70 31	10·5004	71 7	10·4883	71 39	10·4764	5 36
6 20	73 3	10·5215	73 34	10·5086	74 5	10·4961	74 32	10·4838	5 40
6 16	76 18	10·5290	76 44	10·5161	77 9	10·5037	77 31	10·4911	5 44
6 12	79 37	10·5346	79 57	10·5210	80 17	10·5079	80 34	10·4950	5 48
6 8	83 2	10·5386	83 16	10·5242	83 29	10·5109	83 41	10·4977	5 52
6 4	86 30	10·5408	86 37	10·5264	86 44	10·5131	86 50	10·4999	5 56
6 0	90 0	10·5425	90 0	10·5284	90 0	10·5147	90 0	10·5013	6 0

TABLE III.—DECLINATION.

Apparent Time	18° 0′		18° 30′		19° 0′		19° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		′		° ′		H. M.
11 56	18 0	8·2200	18 30	8·2188	19 0	8·2178	19 30	8·2167	12 4
11 52	18 0	8·5212	18 30	8·5200	19 0	8·5190	19 30	8·5179	12 8
11 48	18 1	8·6975	18 31	8·6963	19 1	8·6953	19 31	8·6942	12 12
11 44	18 2	8·8226	18 32	8·8214	19 2	8·8204	19 32	8·8193	12 16
11 40	18 3	8·9199	18 33	8·9187	19 3	8·9179	19 34	8·9171	12 20
11 36	18 5	8·9995	18 35	8·9983	19 5	8·9973	19 36	8·9962	12 24
11 32	18 7	9·0669	18 37	9·0657	19 7	9·0647	19 38	9·0636	12 28
11 28	18 10	9·1255	18 40	9·1243	19 11	9·1230	19 41	9·1216	12 32
11 24	18 13	9·1773	18 43	9·1761	19 14	9·1748	19 44	9·1734	12 36
11 20	18 16	9·2238	18 46	9·2226	19 17	9·2212	19 47	9·2198	12 40
11 16	18 19	9·2662	18 49	9·2650	19 20	9·2637	19 50	9·2623	12 44
11 12	18 23	9·3047	18 53	9·3035	19 24	9·3021	19 54	9·3007	12 48
11 8	18 27	9·3405	18 57	9·3392	19 28	9·3378	19 58	9·3364	12 52
11 4	18 31	9·3737	19 1	9·3724	19 32	9·3710	20 3	9·3697	12 56
11 0	18 36	9·4048	19 6	9·4035	19 37	9·4022	20 8	9·4009	1 0
10 56	18 41	9·4330	19 11	9·4317	19 42	9·4303	20 13	9·4289	1 4
10 52	18 47	9·4607	19 17	9·4594	19 48	9·4580	20 19	9·4565	1 8
10 48	18 52	9·4869	19 23	9·4855	19 54	9·4841	20 26	9·4826	1 12
10 44	18 56	9·5128	19 29	9·5114	20 1	9·5099	20 32	9·5084	1 16
10 40	19 0	9·5366	19 36	9·5352	20 8	9·5337	20 39	9·5322	1 20
10 36	19 11	9·5594	19 43	9·5580	20 15	9·5565	20 46	9·5549	1 24
10 32	19 19	9·5813	19 51	9·5799	20 24	9·5783	20 55	9·5767	1 28
10 28	19 27	9·6025	19 59	9·6010	20 32	9·5994	21 4	9·5978	1 32
10 24	19 35	9·6218	20 7	9·6213	20 40	9·6197	21 13	9·6181	1 36
10 20	19 44	9·6426	20 16	9·6410	20 49	9·6394	21 22	9·6379	1 40
10 16	19 53	9·6618	20 25	9·6601	20 58	9·6585	21 31	9·6569	1 44
10 12	20 2	9·6801	20 35	9·6786	21 8	9·6770	21 40	9·6753	1 48
10 8	20 12	9·6981	20 45	9·6966	21 18	9·6949	21 51	9·6932	1 52
10 4	20 23	9·7158	20 56	9·7142	21 29	9·7125	22 2	9·7108	1 56
10 0	20 34	9·7328	21 7	9·7312	21 41	9·7269	22 14	9·7256	2 0
9 56	20 46	9·7495	21 19	9·7479	21 53	9·7462	22 27	9·7444	2 4
9 52	20 58	9·7661	21 32	9·7643	22 6	9·7626	22 40	9·7608	2 8
9 48	21 11	9·7821	21 45	9·7804	22 19	9·7786	22 53	9·7768	2 12
9 44	21 25	9·7980	21 59	9·7962	22 34	9·7944	23 8	9·7926	2 16
9 40	21 38	9·8136	22 13	9·8117	22 48	9·8099	23 23	9·8080	2 20
9 36	21 53	9·8288	22 28	9·8270	23 3	9·8256	23 38	9·8232	2 24
9 32	22 9	9·8438	22 44	9·8420	23 20	9·8401	23 55	9·8381	2 28
9 28	22 25	9·8587	23 1	9·8568	23 37	9·8548	24 12	9·8528	2 32
9 24	22 42	9·8734	23 18	9·8715	23 54	9·8695	24 30	9·8674	2 36
9 20	23 0	9·8877	23 36	9·8859	24 13	9·8838	24 49	9·8817	2 40
9 16	23 18	9·9024	23 55	9·9002	24 32	9·8978	25 8	9·8954	2 44
9 12	23 37	9·9163	24 14	9·9143	24 51	9·9122	25 28	9·9100	2 48
9 8	23 57	9·9307	24 35	9·9284	25 8	9·9265	25 50	9·9240	2 52
9 4	24 19	9·9545	24 57	9·9422	25 35	9·9400	26 13	9·9375	2 56
9 0	24 41	9·9584	25 19	9·9561	25 58	9·9537	26 36	9·9513	3 0

TABLE III.—DECLINATION.

Apparent Time.	18° 0′		18° 30′		19° 0′		19° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	25 5	9·9725	25 44	9·9702	26 23	9·9679	27 2	9·9655	3 4
8 52	25 29	9·9860	26 9	9·9836	26 48	9·9812	27 28	9·9787	3 8
8 48	25 54	9·9996	20 34	9·9971	27 14	9·9946	27 54	9·9920	3 12
8 44	26 21	10·0151	27 1	10·0106	27 41	10·0080	28 21	10·0053	3 16
8 40	26 49	10·0267	27 30	10·0241	28 10	10·0214	28 51	10·0186	3 20
8 36	27 18	10·0403	28 0	10·0376	28 41	10·0348	29 22	10·0319	3 24
8 32	27 49	10·0539	28 31	10·0511	29 13	10·0482	29 54	10·0452	3 28
8 28	28 22	10·0674	29 4	10·0645	29 46	10·0615	30 28	10·0584	3 32
8 24	28 56	10·0808	29 39	10·0778	30 21	10·0747	31 4	10·0715	3 36
8 20	29 32	10·0943	30 15	10·0912	30 58	10·0880	31 42	10·0847	3 40
8 16	30 10	10·1078	30 53	10·1046	31 36	10·1013	32 21	10·0979	3 44
8 12	30 49	10·1214	31 33	10·1180	32 17	10·1145	33 1	10·1109	3 48
8 8	31 31	10·1352	32 16	10·1317	33 1	10·1281	33 46	10·1244	3 52
8 4	32 15	10·1487	33 1	10·1451	33 47	10·1414	34 33	10·1376	3 56
8 0	33 1	10·1621	33 47	10·1583	34 32	10·1544	35 18	10·1504	4 0
7 56	33 50	10·1755	34 36	10·1715	35 21	10·1674	36 6	10·1633	4 4
7 52	34 42	10·1892	35 27	10·1850	36 13	10·1807	36 59	10·1764	4 8
7 48	35 36	10·2030	36 23	10·1986	37 10	10·1941	37 57	10·1896	4 12
7 44	36 35	10·2166	37 23	10·2120	38 10	10·2073	38 58	10·2026	4 16
7 40	37 36	10·2303	38 24	10·2255	39 12	10·2206	40 0	10·2157	4 20
7 36	38 37	10·2442	39 25	10·2392	40 13	10·2341	41 1	10·2289	4 24
7 32	39 43	10·2595	40 31	10·2537	41 19	10·2478	42 7	10·2418	4 28
7 28	40 55	10·2725	41 45	10·2666	42 35	10·2687	43 25	10·2548	4 32
7 24	42 12	10·2855	43 1	10·2796	43 50	10·2736	44 39	10·2677	4 36
7 20	43 32	10·2999	44 20	10·2938	45 8	10·2875	45 56	10·2813	4 40
7 16	44 57	10·3124	45 47	10·3060	46 36	10·2995	47 25	10·2930	4 44
7 12	46 26	10·3265	47 15	10·3197	48 3	10·3129	48 52	10·3060	4 48
7 8	47 59	10·3407	48 49	10·3336	49 38	10·3264	50 28	10·3192	4 52
7 4	49 39	10·3535	50 28	10·3460	51 17	10·3385	52 6	10·3310	4 56
7 0	51 27	10·3664	52 14	10·3585	53 1	10·3506	53 48	10·3428	5 0
6 56	53 20	10·3789	54 5	10·3706	54 54	10·3623	55 35	10·3541	5 4
6 52	55 20	10·3907	56 0	10·3820	56 50	10·3733	57 33	10·3648	5 8
6 48	57 23	10·4041	58 7	10·3949	58 50	10·3858	59 33	10·3768	5 12
6 44	59 33	10·4188	60 15	10·4092	60 56	10·3998	61 38	10·3905	5 16
6 40	61 53	10·4283	62 32	10·4182	63 11	10·4035	63 50	10·3989	5 20
6 36	64 18	10·4376	64 55	10·4272	65 32	10·4172	66 39	10·4074	5 24
6 32	66 49	10·4474	67 23	10·4370	67 57	10·4263	68 31	10·4157	5 28
6 28	69 26	10·4566	69 57	10·4453	70 28	10·4342	70 59	10·4233	5 32
6 24	72 10	10·4645	72 38	10·4528	73 5	10·4413	73 32	10·4300	5 36
6 20	74 59	10·4715	75 23	10·4593	75 46	10·4473	76 9	10·4360	5 40
6 16	77 53	10·4774	78 12	10·4653	78 31	10·4539	78 50	10·4431	5 44
6 12	80 51	10·4819	81 6	10·4695	81 20	10·4575	81 35	10·4459	5 48
6 8	83 52	10·4855	84 2	10·4728	84 12	10·4607	84 22	10·4475	5 52
6 4	86 55	10·4876	87 0	10·4742	87 5	10·4613	87 10	10·4491	5 56
6 0	90 0	10·4882	90 0	10·4755	90 0	10·4630	90 0	10·4509	6 0

TABLE III.—DECLINATION.

Apparent Time.	20° 0′		20° 30′		21° 0′		21° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	20 0	8·2157	20 30	8·2146	21 0	8·2119	21 30	8·2105	12 4
11 52	20 0	8·5169	20 30	8·5158	21 1	8·5131	21 31	8·5117	12 8
11 48	20 1	8·6932	20 31	8·6921	21 2	8·6894	21 32	8·6880	12 12
11 44	20 2	8·8183	20 32	8·8172	21 3	8·8146	21 33	8·8132	12 16
11 40	20 4	8·9163	20 34	8·9155	21 4	8·9119	21 34	8·9105	12 20
11 36	20 6	8·9952	20 36	8·9941	21 6	8·9914	21 36	8·9900	12 24
11 32	20 8	9·0626	20 38	9·0615	21 8	9·0588	21 38	9·0574	12 28
11 28	20 11	9·1202	20 41	9·1188	21 11	9·1174	21 41	9·1160	12 32
11 24	20 14	9·1720	20 44	9·1706	21 14	9·1691	21 44	9·1677	12 36
11 20	20 17	9·2184	20 47	9·2170	21 18	9·2155	21 48	9·2141	12 40
11 16	20 21	9·2609	20 51	9·2595	21 22	9·2578	21 52	9·2563	12 44
11 12	20 25	9·2993	20 55	9·2979	21 26	9·2964	21 56	9·2949	12 48
11 8	20 29	9·3350	20 59	9·3336	21 30	9·3320	22 1	9·3306	12 52
11 4	20 34	9·3682	21 4	9·3668	21 35	9·3652	22 6	9·3637	12 56
11 0	20 39	9·3996	21 9	9·3978	21 40	9·3962	22 11	9·3947	1 0
10 56	20 44	9·4275	21 15	9·4260	21 46	9·4254	22 17	9·4238	1 4
10 52	20 50	9·4551	21 21	9·4536	21 52	9·4530	22 23	9·4514	1 8
10 48	20 57	9·4811	21 28	9·4796	21 59	9·4790	22 30	9·4774	1 12
10 44	21 4	9·5069	21 35	9·5054	22 6	9·5038	22 37	9·5022	1 16
10 40	21 11	9·5307	21 42	9·5291	22 13	9·5275	22 44	9·5259	1 20
10 36	21 19	9·5533	21 49	9·5517	22 21	9·5502	22 52	9·5486	1 24
10 32	21 28	9·5751	21 58	9·5735	22 30	9·5718	23 1	9·5702	1 28
10 28	21 37	9·5955	22 8	9·5946	22 39	9·5930	23 10	9·5914	1 32
10 24	21 46	9·6165	22 18	9·6148	22 49	9·6133	23 20	9·6116	1 36
10 20	21 55	9·6362	22 27	9·6346	22 57	9·6328	23 30	9·6311	1 40
10 16	22 4	9·6552	22 36	9·6549	23 8	9·6518	23 40	9·6500	1 44
10 12	22 13	9·6736	22 45	9·6719	23 18	9·6702	23 51	9·6684	1 48
10 8	22 24	9·6878	22 56	9·6856	23 30	9·6838	24 3	9·6818	1 52
10 4	22 35	9·7090	23 8	9·7074	23 42	9·7055	24 15	9·7037	1 56
10 0	22 48	9·7261	23 21	9·7243	23 55	9·7225	24 28	9·7206	2 0
9 56	23 1	9·7427	23 34	9·7409	24 8	9·7390	24 42	9·7371	2 4
9 52	23 14	9·7590	23 47	9·7572	24 22	9·7552	24 56	9·7533	2 8
9 48	23 27	9·7750	24 1	9·7732	24 36	9·7712	25 10	9·7692	2 12
9 44	23 42	9·7908	24 16	9·7889	24 51	9·7871	25 25	9·7851	2 16
9 40	23 58	9·8061	24 32	9·8042	25 7	9·8028	25 31	9·8007	2 20
9 36	24 13	9·8213	24 48	9·8193	25 23	9·8172	25 58	9·8151	2 24
9 32	24 30	9·8362	25 5	9·8342	25 41	9·8319	26 16	9·8298	2 28
9 28	24 48	9·8508	25 23	9·8488	25 59	9·8466	26 34	9·8444	2 32
9 24	25 6	9·8653	25 41	9·8632	26 17	9·8609	26 53	9·8587	2 36
9 20	25 25	9·8796	26 1	9·8774	26 37	9·8750	27 13	9·8728	2 40
9 16	25 45	9·8935	26 21	9·8915	26 58	9·8890	27 34	9·8868	2 44
9 12	26 5	9·9056	26 42	9·9054	27 19	9·9030	27 55	9·9006	2 48
9 8	26 28	9·9216	27 5	9·9193	27 41	9·9168	28 18	9·9143	2 52
9 4	26 51	9·9353	27 29	9·9327	28 5	9·9302	28 42	9·9277	2 56
9 0	27 14	9·9589	27 52	9·9465	28 30	9·9439	29 7	9·9413	3 0

TABLE III.—DECLINATION.

Apparent Time.	20° 0′		20° 30′		21° 0′		21° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	27 40	9·9630	28 19	9·9605	28 57	9·9580	29 35	9·9556	3 4
8 52	28 6	9·9761	28 45	9·9735	29 24	9·9708	30 2	9·9681	3 8
8 48	28 33	9·9893	29 12	9·9866	29 51	9·9838	30 30	9·9810	3 12
8 44	29 1	10·0025	29 41	9·9997	30 20	9·9967	30 58	9·9938	3 16
8 40	29 31	10·0157	31 11	10·0128	30 51	10·0097	31 30	10·0067	3 20
8 36	30 3	10·0289	30 43	10·0259	31 23	10·0229	32 3	10·0198	3 24
8 32	30 36	10·0421	31 16	10·0390	31 56	10·0357	32 36	10·0325	3 28
8 28	31 10	10·0552	31 51	10·0520	32 31	10·0486	33 11	10·0453	3 32
8 24	31 46	10·0682	32 28	10·0649	33 9	10·0616	33 50	10·0582	3 36
8 20	32 24	10·0813	33 6	10·0779	33 48	10·0745	34 29	10·0710	3 40
8 16	33 3	10·0944	33 46	10·0909	34 29	10·0873	35 10	10·0837	3 44
8 12	33 45	10·1073	34 28	10·1036	35 11	10·0999	35 53	10·0961	3 48
8 8	34 30	10·1207	35 13	10·1169	35 55	10·1126	36 36	10·1087	3 52
8 4	35 16	10·1337	36 0	10·1298	36 41	10·1253	37 23	10·1213	3 56
8 0	36 3	10·1463	36 47	10·1422	37 31	10·1380	38 14	10·1338	4 0
7 56	36 51	10·1591	37 37	10·1548	38 22	10·1504	39 5	10·1460	4 4
7 52	37 44	10·1720	38 30	10·1675	39 16	10·1629	39 59	10·1583	4 8
7 48	38 43	10·1850	39 28	10·1803	40 13	10·1756	40 56	10·1707	4 12
7 44	39 45	10·1978	40 30	10·1929	41 14	10·1878	41 58	10·1827	4 16
7 40	40 47	10·2107	41 32	10·2056	42 17	10·2003	43 1	10·1950	4 20
7 36	41 49	10·2237	42 35	10·2184	43 21	10·2131	44 5	10·2076	4 24
7 32	42 55	10·2360	43 41	10·2316	44 27	10·2255	45 11	10·2199	4 28
7 28	44 5	10·2489	44 55	10·2433	45 39	10·2376	46 23	10·2318	4 32
7 24	45 27	10·2618	46 13	10·2559	46 58	10·2499	47 41	10·2439	4 36
7 20	46 54	10·2751	47 32	10·2689	48 20	10·2619	49 3	10·2556	4 40
7 16	48 15	10·2865	49 0	10·2800	49 44	10·2740	50 27	10·2672	4 44
7 12	49 40	10·2991	50 25	10·2922	51 10	10·2855	51 52	10·2784	4 48
7 8	51 17	10·3120	51 59	10·3048	52 40	10·2980	53 22	10·2907	4 52
7 4	52 55	10·3235	53 37	10·3160	54 18	10·3097	54 59	10·3024	4 56
7 0	54 35	10·3350	55 18	10·3272	56 1	10·3193	56 41	10·3116	5 0
6 56	56 20	10·3459	57 4	10·3377	57 48	10·3290	58 26	10·3210	5 4
6 52	58 16	10·3563	58 58	10·3478	59 39	10·3404	60 16	10·3318	5 8
6 48	60 16	10·3679	60 55	10·3590	61 34	10·3503	62 9	10·3416	5 12
6 44	62 9	10·3812	62 38	10·3719	63 36	10·3593	64 9	10·3503	5 16
6 40	64 29	10·3893	65 5	10·3797	65 41	10·3681	66 12	10·3588	5 20
6 36	66 45	10·3976	67 18	10·3878	67 50	10·3770	68 19	10·3674	5 24
6 32	69 4	10·4056	69 34	10·3955	70 4	10·3848	70 31	10·3749	5 28
6 28	71 29	10·4127	71 56	10·4021	72 23	10·3917	72 47	10·3815	5 32
6 24	73 59	10·4193	74 23	10·4086	74 46	10·3979	74 37	10·3875	5 36
6 20	76 32	10·4251	76 52	10·4142	77 12	10·4032	77 30	10·3926	5 40
6 16	79 9	10·4320	79 26	10·4209	79 42	10·4078	79 57	10·3970	5 44
6 12	81 49	10·4347	82 2	10·4235	82 14	10·4113	82 25	10·4004	5 48
6 8	84 31	10·4361	84 40	10·4247	84 48	10·4139	84 56	10·4027	5 52
6 4	87 15	10·4375	87 20	10·4259	87 24	10·4149	87 28	10·4037	5 56
6 0	90 0	10·4389	90 0	10·4273	90 0	10·4158	90 0	10·4046	6 0

TABLE III.—DECLINATION.

Apparent Time.	22° 0′		22° 30′		23° 0′		23° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	22 0	8·2091	22 30	8·2075	23 0	8·2059	23 30	8·2043	12 4
11 52	22 1	8·5102	22 31	8·5086	23 1	8·5070	23 31	8·5054	12 8
11 48	22 2	8·6865	22 32	8·6849	23 2	8·6833	23 32	8·6817	12 12
11 44	22 3	8·8117	22 33	8·8101	23 3	8·8085	23 33	8·8068	12 16
11 40	22 5	8·9090	22 35	8·9074	23 5	8·9058	23 35	8·9040	12 20
11 36	22 7	8·9885	22 37	8·9869	23 7	8·9853	23 37	8·9830	12 24
11 32	22 9	9·0559	22 39	9·0543	23 10	9·0527	23 40	9·0510	12 28
11 28	22 12	9·1145	22 42	9·1129	23 13	9·1112	23 43	9·1095	12 32
11 24	22 15	9·1662	22 45	9·1646	23 16	9·1629	23 46	9·1612	12 36
11 20	22 19	9·2126	22 49	9·2110	23 20	9·2093	23 50	9·2076	12 40
11 16	22 23	9·2548	22 53	9·2531	23 24	9·2514	23 54	9·2497	12 44
11 12	22 27	9·2934	22 57	9·2917	23 28	9·2900	23 58	9·2883	12 48
11 8	22 32	9·3290	23 2	9·3273	23 33	9·3256	24 3	9·3239	12 52
11 4	22 37	9·3621	23 7	9·3604	23 38	9·3587	24 8	9·3570	12 56
11 0	22 42	9·3931	23 13	9·3914	23 44	9·3897	24 14	9·3880	1 0
10 56	22 48	9·4222	23 19	9·4205	23 50	9·4188	24 20	9·4170	1 4
10 52	22 54	9·4498	23 25	9·4481	23 56	9·4464	24 27	9·4446	1 8
10 48	23 1	9·4758	23 32	9·4741	24 4	9·4724	24 34	9·4706	1 12
10 44	23 8	9·5006	23 40	9·4989	24 12	9·4972	24 42	9·4954	1 16
10 40	23 16	9·5242	23 48	9·5225	24 20	9·5207	24 50	9·5189	1 20
10 36	23 24	9·5469	23 56	9·5452	24 28	9·5434	24 58	9·5416	1 24
10 32	23 33	9·5685	24 6	9·5668	24 37	9·5649	25 7	9·5630	1 28
10 28	23 43	9·5897	24 16	9·5880	24 47	9·5861	25 17	9·5842	1 32
10 24	23 53	9·6099	24 26	9·6081	24 57	9·6062	25 27	9·6043	1 36
10 20	24 4	9·9294	24 36	9·6276	25 7	9·6257	25 37	9·6238	1 40
10 16	24 14	9·6482	24 46	9·6464	25 17	9·6445	25 48	9·6425	1 44
10 12	24 24	9·6666	24 56	9·6647	25 28	9·6628	26 0	9·6608	1 48
10 8	24 38	9·6841	25 9	9·6826	25 40	9·6806	26 12	9·6786	1 52
10 4	24 52	9·7018	25 22	9·6998	25 53	9·6978	26 25	9·6957	1 56
10 0	25 6	9·7187	25 35	9·7167	26 7	9·7147	26 39	9·7126	2 0
9 56	25 20	9·7352	25 48	9·7332	26 21	9·7312	26 53	9·7291	2 4
9 52	25 34	9·7514	26 2	9·7495	26 36	9·7475	27 8	9·7455	2 8
9 48	25 48	9·7672	26 17	9·7651	26 52	9·7630	27 24	9·7608	2 12
9 44	26 2	9·7831	26 33	9·7810	27 7	9·7788	27 40	9·7766	2 16
9 40	26 16	9·7986	26 50	9·7965	27 24	9·7943	27 57	9·7920	2 20
9 36	26 33	9·8130	27 7	9·8108	27 41	9·8085	28 15	9·8062	2 24
9 32	26 51	9·8277	27 25	9·8255	28 0	9·8232	28 34	9·8208	2 28
9 28	27 10	9·8422	27 44	9·8400	28 19	6·8376	28 53	9·8352	2 32
9 24	27 29	9·8564	28 4	9·8541	28 39	9·8517	29 14	9·8493	2 36
9 20	27 49	9·8704	28 25	9·8680	28 59	9·8656	29 35	9·8632	2 40
9 16	28 10	9·8844	28 46	9·8820	29 21	9·8795	29 57	9·8770	2 44
9 12	28 32	9·8981	29 8	9·8956	29 44	9·8931	30 20	9·8905	2 48
9 8	28 56	9·9117	29 32	9·9091	30 8	9·9065	30 44	9·9039	2 52
9 4	29 20	9·9241	29 56	9·9215	30 33	9·9188	31 9	9·9174	2 56
9 0	29 44	9·9387	30 21	9·9360	30 58	9·9332	31 35	9·9304	3 0

TABLE III.—DECLINATION.

Apparent Time.	22° 0′		22° 30′		23° 0′		23° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	30 12	9·9529	30 49	9·9502	31 26	9·9474	32 3	9·9445	3 4
8 52	30 40	9·9653	31 18	9·9625	31 55	9·9596	32 32	9·9566	3 8
8 48	31 8	9·9781	31 46	9·9752	32 24	9·9722	33 1	9·9691	3 12
8 44	31 37	9·9908	32 16	9·9878	32 54	9·9847	33 32	9·9815	3 16
8 40	32 9	10·0036	32 48	10·0005	33 26	9·9973	34 5	9·9940	3 20
8 36	32 42	10·0166	33 21	10·0133	34 0	10·0100	34 39	10·0066	3 24
8 32	33 15	10·0292	33 55	10·0258	34 34	10·0224	35 14	10·0189	3 28
8 28	33 51	10·0419	34 31	10·0384	35 10	10·0349	35 50	10·0313	3 32
8 24	34 30	10·0547	35 10	10·0511	35 50	10·0474	36 30	10·0437	3 36
8 20	35 10	10·0674	35 51	10·0637	36 31	10·0599	37 12	10·0561	3 40
8 16	35 51	10·0800	36 32	10·0762	37 13	10·0723	37 53	10·0684	3 44
8 12	36 34	10·0922	37 15	10·0883	37 56	10·0843	38 36	10·0803	3 48
8 8	37 17	10·1047	37 58	10·1007	38 40	10·0966	39 21	10·0925	3 52
8 4	38 4	10·1172	38 45	10·1130	39 26	10·1088	40 9	10·1045	3 56
8 0	38 56	10·1295	39 38	10·1251	40 26	10·1207	41 1	10·1162	4 0
7 56	39 48	10·1416	40 31	10·1371	41 13	10·1326	41 55	10·1280	4 4
7 52	40 42	10·1537	41 25	10·1491	42 8	10·1445	42 50	10·1398	4 8
7 48	41 39	10·1659	42 22	10·1612	43 5	10·1565	43 46	10·1517	4 12
7 44	42 41	10·1777	43 24	10·1728	44 7	10·1678	44 48	10·1628	4 16
7 40	43 44	10·1898	44 27	10·1846	45 10	10·1794	45 51	10·1742	4 20
7 36	44 48	10·2021	45 31	10·1966	46 14	10·1911	46 55	10·1856	4 24
7 32	45 54	10·2143	46 37	10·2087	47 20	10·2030	48 2	10·1973	4 28
7 28	47 6	10·2260	47 50	10·2200	48 33	10·2143	49 14	10·2084	4 32
7 24	48 24	10·2379	49 7	10·2318	49 50	10·2257	50 30	10·2195	4 36
7 20	49 45	10·2492	50 28	10·2427	51 10	10·2362	51 49	10·2296	4 40
7 16	51 9	10·2605	51 51	10·2536	52 33	10·2467	53 11	10·2397	4 44
7 12	52 34	10·2712	53 16	10·2643	53 57	10·2579	54 36	10 2511	4 48
7 8	54 4	10·2834	54 16	10·2760	55 27	10·2686	56 5	10·2611	4 52
7 4	55 40	10·2949	56 21	10·2874	57 1	10·2799	57 38	10·2723	4 56
7 0	57 20	10·3039	57 59	10·2963	58 38	10·2887	59 14	10·2810	5 0
6 56	59 4	10·3130	59 42	10·3051	60 19	10·2972	60 54	10·2893	5 4
6 52	60 52	10·3235	61 24	10·3153	62 4	10·3071	62 38	10·2989	5 8
6 48	62 44	10·3330	63 19	10·3245	63 54	10·3160	64 27	10·3076	5 12
6 44	64 42	10·3414	65 15	10·3326	65 48	10·3238	66 18	10·3151	5 16
6 40	66 43	10·3496	67 14	10·3405	67 44	10·3315	68 13	10·3225	5 20
6 36	68 48	10·3579	69 17	10·3485	69 46	10·3392	70 12	10·3300	5 24
6 32	70 49	10·3652	71 15	10·3557	71 51	10·3463	72 15	10·3370	5 28
6 28	73 4	10·3715	73 29	10·3617	73 59	10·3521	74 21	10·3425	5 32
6 24	75 25	10·3773	75 46	10·3673	76 10	10·3573	46 29	10·3478	5 36
6 20	77 48	10·3822	78 6	10·3720	78 24	10·3620	78 40	10·3522	5 40
6 16	80 11	10·3863	80 26	10·3758	80 40	10·3655	80 53	10·3553	5 44
6 12	82 36	10·3897	82 47	10·3792	82 58	10·3689	83 8	10·3589	5 48
6 8	85 3	10·3917	85 11	10·3812	85 18	10·3705	85 25	10·3601	5 52
6 4	87 32	10·3928	87 36	10·3823	87 39	10·3717	87 42	10·3615	5 56
6 0	90 0	10·3936	90 0	10·3828	90 0	10·3721	90 0	10·3617	6 0

TABLE III.—DECLINATION.

Apparent Time.	24° 0′		24° 30′		25° 0′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		H. M.
11 56	24 0	8·2025	24 30	8·2008	25 0	8·1991	12 4
11 52	24 1	8·5037	24 31	8·5020	25 1	8·5003	12 8
11 48	24 2	8·6860	24 32	8·6783	25 2	8·6766	12 12
11 44	24 3	8·8051	24 33	8·8034	25 3	8·8017	12 16
11 40	24 5	8·9022	24 35	8·9005	25 5	8·8988	12 20
11 36	24 7	8·9819	24 37	8·9802	25 7	8·9784	12 24
11 32	24 9	9·0493	24 39	9·0476	25 10	9·0458	12 28
11 28	24 12	9·1078	24 42	9·1961	25 13	9·1943	12 32
11 24	24 16	9·1595	24 46	9·1578	25 17	9·1560	12 36
11 20	24 20	9·2059	24 50	9·2042	25 21	9·2024	12 40
11 16	24 24	9·2480	24 54	9·2464	25 25	9·2446	12 44
11 12	24 29	9·2865	24 59	9·2848	25 30	9·2830	12 48
11 8	24 34	9·3221	25 4	9·3204	25 35	9·3186	12 52
11 4	24 39	9·3552	25 10	9·3535	25 41	9·3527	12 56
11 0	24 45	9·3862	25 16	9·3845	25 47	9·3827	1 0
10 56	24 51	9·4153	25 22	9·4135	25 53	9·4111	1 4
10 52	24 58	9·4428	25 29	9·4410	26 0	9·4391	1 8
10 48	24 5	9·4687	25 36	9·4669	26 7	9·4650	1 12
10 44	25 12	9·4935	25 44	9·4916	26 15	9·4897	1 16
10 40	25 20	9·5170	25 52	9·5152	26 24	9·5133	1 20
10 36	25 30	9·5397	26 1	9·5378	26 33	9·5359	1 24
10 32	25 39	9·5613	26 11	9·5594	26 43	9·5575	1 28
10 28	25 49	9.5822	26 21	9·5803	26 53	9·5784	1 32
10 24	25 59	9·6022	26 31	9·6003	27 3	9·5984	1 36
10 20	26 10	9·6217	26 42	9·6197	27 14	9·6177	1 40
10 16	26 22	9·6405	26 53	9·6385	27 26	9·6365	1 44
10 12	26 33	9·6588	27 5	9·6568	27 38	9·6548	1 48
10 8	26 45	9·6764	27 18	9·6743	27 51	9·6722	1 52
10 4	26 58	9·6937	27 31	9·6916	28 4	9·6895	1 56
10 0	26 12	9·7104	27 45	9·7083	28 18	9·7062	2 0
9 56	27 27	9·7269	28 0	9·7247	28 33	9·7235	2 4
9 52	27 42	9·7428	28 15	9·7406	28 48	9·7384	2 8
9 48	27 58	9·7585	28 31	9·7563	29 4	9·7541	2 12
9 44	28 14	9·7740	28 48	9·7717	29 21	9·7694	2 16
9 40	28 31	9·7890	29 5	9·7867	29 39	9·7844	2 20
9 36	28 49	9·8038	29 23	9·8015	29 57	9·7992	2 24
9 32	29 8	9·8183	29 42	9·8159	30 16	9·8135	2 28
9 28	29 28	9·8325	30 2	9·8301	30 37	9·8277	2 32
9 24	29 49	9.8466	30 23	9·8442	30 58	9·8418	2 36
9 20	30 10	9.8605	30 45	9·8589	31 20	9·8555	2 40
9 16	30 33	9·8742	31 8	9·8717	31 43	9·8692	2 44
9 12	30 56	9·8877	31 31	9·8851	32 6	9·8825	2 48
9 8	31 20	9·9010	31 55	9·8984	32 30	9·8957	2 52
9 4	31 45	9·9142	32 21	9·9115	32 56	9·9088	2 56
9 0	32 12	9·9274	32 48	9·9246	33 24	9·9218	3 0

TABLE III.—DECLINATION.

Apparent Time.	24° 0′		24° 30′		25° 0′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		H. M.
8 56	32 40	9·9412	33 17	9·9383	33 53	9·9354	3 4
8 52	33 9	9·9535	33 46	9·9505	34 22	9·9475	3 8
8 48	33 38	9·9660	34 16	9·9629	34 52	9·9598	3 12
8 44	34 9	9·9784	34 46	9·9752	35 23	9·9720	3 16
8 40	34 42	9·9910	35 20	9·9877	35 57	9·9844	3 20
8 36	35 17	10·0035	35 55	10·0001	36 32	9·9996	3 24
8 32	35 53	10·0159	36 31	10·0124	37 8	10·0088	3 28
8 28	36 30	10·0281	37 8	10·0245	37 45	10·0208	3 32
8 24	37 9	10·0402	37 47	10·0364	38 25	10·0326	3 36
8 20	37 50	10·0523	38 28	10·0484	39 5	10·0445	3 40
8 16	38 32	10·0643	39 10	10·0603	39 48	10·0563	3 44
8 12	39 16	10·0764	39 55	10·0723	40 34	10·0682	3 48
8 8	40 3	10·0882	40 43	10·0840	41 22	10·0798	3 52
8 4	40 51	10·0994	41 31	10·0951	42 11	10·0907	3 56
8 0	41 41	10·1118	42 20	10·1073	42 59	10·1027	4 0
7 56	42 36	10·1232	43 16	10·1186	43 55	10·1139	4 4
7 52	43 32	10·1347	44 11	10·1300	44 50	10·1252	4 8
7 48	44 27	10·1464	45 6	10·1415	45 45	10·1365	4 12
7 44	45 29	10·1582	46 8	10·1531	46 47	10·1479	4 16
7 40	46 31	10·1697	47 10	10·1644	47 49	10·1590	4 20
7 36	47 35	10·1804	48 14	10·1748	48 53	10·1692	4 24
7 32	48 43	10·1910	49 22	10·1852	50 1	10·1794	4 28
7 28	49 54	10·2019	50 33	10·1959	51 11	10·1853	4 32
7 24	51 10	10·2131	51 48	10·2069	52 26	10·2007	4 36
7 20	52 28	10·2238	53 6	10·2173	53 43	10·2105	4 40
7 16	53 48	10·2340	54 25	10·2282	55 2	10·2211	4 44
7 12	55 14	10·2442	55 50	10·2370	56 26	10·2302	4 48
7 8	56 42	10·2547	57 16	10·2474	57 53	10·2399	4 52
7 4	58 15	10·2644	58 50	10·2571	59 24	10·2492	4 56
7 0	59 50	10·2731	60 24	10·2655	60 57	10·2578	5 0
6 56	61 28	10·2820	62 1	10·2742	62 33	10·2672	5 4
6 52	63 12	10·2906	63 43	10·2826	64 14	10·2753	5 8
6 48	64 58	10·2990	65 28	10·2907	65 57	10·2824	5 12
6 44	66 48	10·3066	67 16	10·2981	67 43	10·2897	5 16
6 40	68 41	10·3139	69 7	10·3051	69 32	10·2964	5 20
6 36	70 38	10·3208	71 2	10·3117	71 26	10·3027	5 24
6 32	72 38	10·3270	73 0	10·3178	73 21	10·3086	5 28
6 28	74 42	10·3325	75 1	10·3231	75 20	10·3138	5 32
6 24	76 47	10·3374	77 4	10·3278	77 21	10·3183	5 36
6 20	78 55	10·3416	79 10	10·3320	79 24	10·3223	5 40
6 16	81 6	10·3451	81 18	10·3353	81 29	10·3256	5 44
6 12	83 18	10·3478	83 27	10·3378	83 36	10·3280	5 48
6 8	85 31	10·3499	85 37	10·3399	85 43	10·3299	5 52
6 4	87 45	10·3513	87 48	10·3413	87 51	10·3313	5 56
6 0	90 0	10·3514	90 0	10·3413	90 0	10·3313	6 0

TABLE III.—DECLINATION.

Apparent Time.	25° 30′		26° 0′		26° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		H. M.
11 56	25 30	8·1973	26 0	8·1955	26 30	8·1936	12 4
11 52	25 31	8·4985	26 1	8·4967	26 31	8·4948	12 8
11 48	25 32	8·6748	26 2	8·6730	26 32	8·6711	12 12
11 44	25 33	8·7999	26 3	8·7980	26 33	8·7962	12 16
11 40	25 35	8·8970	26 5	8·8951	26 35	8·8932	12 20
11 36	25 37	8·9766	26 7	8·9748	26 37	8·9729	12 24
11 32	25 40	9·0440	26 10	9·0421	26 40	9·0402	12 28
11 28	25 43	9·1025	26 13	9·1006	26 43	9·0987	12 32
11 24	25 47	9·1542	26 17	9·1523	26 47	9·1504	12 36
11 20	25 51	9·2000	26 21	9·1985	26 51	9·1966	12 40
11 16	25 55	9·2428	26 25	9·2409	26 55	9·2390	12 44
11 12	26 0	9·2812	26 30	9·2793	27 0	9·2774	12 48
11 8	26 5	9·3167	26 36	9·3147	27 6	9·3127	12 52
11 4	26 11	9·3498	26 42	9·3478	27 12	9·3458	12 56
11 0	26 17	9·3808	26 48	9·3788	27 18	9·3768	1 0
10 56	26 23	9·4097	26 55	9·4077	27 25	9·4057	1 4
10 52	26 30	9·4372	27 2	9·4352	27 32	9·4332	1 8
10 48	26 38	9·4631	27 9	9·4611	27 40	9·4591	1 12
10 44	26 46	9·4877	27 17	9·4856	27 48	9·4835	1 16
10 40	26 55	9·5113	27 26	9·5092	27 57	9·5070	1 20
10 36	27 4	9·5339	27 35	9·5318	28 6	9·5297	1 24
10 32	27 14	9·5555	27 45	9·5534	28 16	9·5512	1 28
10 28	27 24	9·5764	27 55	9·5743	28 26	9·5721	1 32
10 24	27 34	9·5964	28 6	9·5943	28 37	9·5921	1 36
10 20	27 45	9·6156	28 17	9·6134	28 49	9·6112	1 40
10 16	27 57	9·6344	28 29	9·6322	29 1	9·6299	1 44
10 12	28 10	9·6527	28 42	9·6505	29 14	9·6481	1 48
10 8	28 23	9·6700	28 55	9·6677	29 27	9·6652	1 52
10 4	28 37	9·6873	29 9	9·6850	29 41	9·6826	1 56
10 0	28 51	9·7040	29 24	9·7017	29 56	9·6992	2 0
9 56	29 6	9·7202	29 39	9·7178	30 11	9·7153	2 4
9 52	29 21	9·7361	29 54	9·7337	30 27	9·7311	2 8
9 48	29 37	9·7518	30 10	9·7494	30 43	9·7468	2 12
9 44	29 54	9·7670	30 27	9·7645	31 1	9·7619	2 16
9 40	30 12	9·7820	30 45	9·7794	31 19	9·7767	2 20
9 36	30 31	9·7967	31 5	9·7941	31 38	9·7904	2 24
9 32	30 50	9·8110	31 25	9·8083	31 58	9·8055	2 28
9 28	31 11	9·8251	31 46	9·8224	32 19	9·8196	2 32
9 24	31 32	9·8392	32 7	9·8365	32 41	9·8336	2 36
9 20	31 54	9·8528	32 29	9·8502	33 3	9·8472	2 40
9 16	32 17	9·8665	32 52	9·8638	33 26	9·8606	2 44
9 12	32 41	9·8797	33 16	9·8768	33 51	9·8737	2 48
9 8	33 6	9·8928	33 41	9·8898	34 17	9·8866	2 52
9 4	*33 33*	9·9039	34 7	9·9029	34 44	9·8997	2 56
9 0	*34 0*	9·9188	34 36	9·9157	35 11	9·9124	3 0

TABLE III.—DECLINATION.

Apparent Time.	25° 30′		26° 0′		26° 30′		Apparent Time.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		H. M.
8 56	34 29	9·9324	35 5	9·9282	35 40	9·9250	3 4
8 52	34 59	9·9444	35 35	9·9406	36 10	9·9373	3 8
8 48	35 30	9·9566	36 5	9·9531	36 41	9·9497	3 12
8 44	36 0	9·9687	36 37	9·9654	37 15	9·9619	3 16
8 40	36 34	9·9810	37 11	9·9776	37 49	9·9740	3 20
8 36	37 10	9·9930	37 47	9·9895	38 23	9·9858	3 24
8 32	37 46	10·0051	38 23	10·0014	39 0	9·9976	3 28
8 28	38 23	10·0170	39 0	10·0134	39 38	10·0095	3 32
8 24	39 3	10·0287	39 41	10·0249	40 18	10·0210	3 36
8 20	39 43	10·0405	40 20	10·0365	41 0	10·0325	3 40
8 16	40 26	10·0522	41 4	10·0480	41 43	10·0439	3 44
8 12	41 13	10·0640	41 51	10·0596	42 28	10·0554	3 48
8 8	42 2	10·0755	42 41	10·0712	43 14	10·0669	3 52
8 4	42 51	10·0863	43 30	10·0818	44 3	10·0773	3 56
8 0	43 41	10·0981	44 17	10·0934	44 53	10·0887	4 0
7 56	44 34	10·1092	45 13	10·1044	45 45	10·0993	4 4
7 52	45 29	10·1208	46 7	10·1158	46 42	10·1108	4 8
7 48	46 24	10·1312	47 3	10·1261	47 41	10·1210	4 12
7 44	47 26	10·1420	48 5	10·1367	48 41	10·1314	4 16
7 40	48 28	10·1528	49 7	10·1473	49 43	10·1418	4 20
7 36	49 32	10·1646	50 10	10·1588	50 47	10·1522	4 24
7 32	50 40	10·1733	51 18	10·1689	51 55	10·1629	4 28
7 28	51 50	10·1847	52 28	10·1787	53 5	10·1726	4 32
7 24	53 4	10·1944	53 42	10·1882	54 17	10·1820	4 36
7 20	54 21	10·2037	54 58	10·1974	55 33	10·1911	4 40
7 16	55 39	10·2140	56 16	10·2075	56 51	10·2010	4 44
7 12	57 2	10·2234	57 38	10·2167	58 12	10·2100	4 48
7 8	58 29	10·2323	59 4	10·2254	59 37	10·2185	4 52
7 4	59 58	10·2414	60 32	10·2342	61 5	10·2270	4 56
7 0	61 30	10·2504	62 3	10·2429	62 34	10·2354	5 0
6 56	63 5	10·2601	63 37	10·2524	64 6	10·2447	5 4
6 52	64 45	10·2679	65 15	10·2600	65 42	10·2521	5 8
6 48	66 26	10·2741	66 55	10·2660	67 22	10·2579	5 12
6 44	68 10	10·2813	68 37	10·2730	69 4	10·2647	5 16
6 40	69 58	10·2879	70 23	10·2794	70 48	10·2907	5 20
6 36	71 50	10·2940	72 13	10·2852	72 35	10·2765	5 24
6 32	73 43	10·2994	74 4	10·2906	74 24	10·2818	5 28
6 28	75 39	10·3047	75 58	10·2956	79 16	10·2865	5 32
6 24	77 38	10·3088	77 54	10·2997	78 10	10·2906	5 36
6 20	79 38	10·3126	79 52	10·3033	80 5	10·2940	5 40
6 16	81 41	10·3159	81 52	10·3064	82 2	10·2971	5 44
6 12	83 45	10·3182	83 53	10·3088	84 0	10·2994	5 48
6 8	85 49	10·3198	85 54	10·3104	86 0	10·3010	5 52
6 4	87 54	10·3215	87 57	10·3115	88 0	10·3021	5 56
6 0	90 0	10·3215	90 0	10·3118	90 0	10·3023	6 0

TABLE IV.—The NUMBER of the STARS in Table VII. that are in best Position for having their Azimuths observed at different Latitudes for each Hour of Sidereal Time.

Latitude North.	SIDEREAL TIME.												Latitude North.
Degrees.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Degrees.
0	E. 2. 14. 1.	2. 3. 14. 1.	2. 4. 5. 15. 16.	16. 4. 5. 15.	18. 15.	17. 18. 6.	17. 6. 7.	17. 7.	19. 20. 7.	9. 19. 20.	21. 9. 22. 8. 7.	21. 19. 8.	0
	W. 11. 24.	11. 24.		12.	12. 13.	13.	13.		2.	2. 1. 14. 15.	14. 15. 3. 2.	15. 16. 17. 4.	
10	E. 2. 14. 1. 13.	2. 3. 14. 13.	16. 3. 4. 2. 5.	16. 15. 5. 4.	15.	18. 15. 6. 7.	7. 6. 15. 18.	7. 17.	17. 20. 8. 7.	17. 9. 20. 19.	19. 22. 9. 8.	19. 21. 22.	10
	W. 10. 11.	11.	13.	12. 13.	12. 13.	13.		15.	15. 2. 1.	1. 14. 15.	2. 15. 14.	3. 16.	
20	E. 13. 2. 1.	13. 14. 3. 2.	16. 4.	16. 5. 4.	7. 15.	15. 18. 16. 7.	15. 7. 6.	7. 8.	8.	9. 20.	22. 9.	22.	20
	W. 10. 11.	11.	13.	13.	12.			15.	15.	1. 15. 14.	2. 3. 14.	2. 3. 16.	
30	E. 1. 2.	3. 4. 14.	3. 4. 14. 16.	16. 5. 7.	7. 15.	6. 18. 7.	15. 6. 18.	8.	8. 9.	9. 20.	9. 20.	22.	30
	W. 10. 11.	10. 11.		12.	12.			15.	14. 1.	1. 14. 16.	2. 16. 3.	2. 16. 3.	
40	E. 1. 3.	4. 3. 14.	4. 3. 14. 5.	7. 5. 4.	6. 7. 16.	6. 8. 16.	18. 6. 8.	8. 18.	8.	9. 20.	9. 20.	22. 20.	40
	W. 10. 11.	10. 11.	10.	12.	12.	12.	14.	16. 14.	16. 14. 1.	16. 14. 3. 1.	16. 3. 1.	2. 3. 5.	
50	E. 4. 1. 7.	4. 3. 7.	4. 3. 7. 14.	14. 5. 7.	16. 5. 14.	16. 14. 6. 8.	16. 18. 6. 8.	18. 8.	9. 18.	18. 9.	20. 10. 9.	10. 20.	50
	W. 10. 8. 11.	10. 11.	10.	10. 12.	12.	12.	14.	16. 14.	16. 14. 1.	16. 14. 2. 1.	1. 3. 16. 5.	2. 3. 5. 18.	
60	E. 1. 4. 7.	1. 3. 4. 7.	3. 4. 8.	14. 5. 3. 8.	14. 5. 6. 8.	14. 5. 6. 8.	16. 5. 18. 6.	9. 10. 18. 6.	9. 10. 18.	9. 10. 18.	10. 9. 18.	10. 9. 20.	60
	W. 10. 11.	10. 11.	10. 12.	10. 12.	10. 12.	10. 12.	10. 14.	16. 14.	14. 16. 3. 1.	16. 3. 5. 1.	5. 3. 1. 18.	3. 5. 18. 1.	

Latitude North.	SIDEREAL TIME.												Latitude North.
Degrees.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Degrees.
0	E. 21. 19. 23.	21. 23.	10. 21.	11. 10.	24. 11.	24.	24. 12.	12. 24.	24.	13.	13.	1. 13.	0
	W. 17. 16. 7. 4.	7. 18.	7. 18. 19. 6.	7. 6. 19. 21.	19. 21. 8.	20. 21. 8. 9.	21. 9. 20. 8.	9. 21. 22.	22. 23.	23. 24. 10.	10. 24.	10. 24.	
10	E. 21. 23.	21. 10. 23.	21. 10.	10. 11.	11.	24.	12. 24.	12. 24.	24.		13.	13. 1.	10
	W. 4. 5.	19. 18. 7.	19. 6. 7.	21. 19. 7.	21. 7.	21. 20. 8.	20. 8. 21.	9. 22. 8.	23.	24. 23.	24. 10.	24. 10.	
20	E. 23.	10. 23. 21.	10. 21. 23.	11.	11.		12.	12. 24.				1. 2.	20
	W. 4. 5.	18. 4. 5.	6. 18.	21. 6. 7.	7. 21.	7. 20.	20. 7. 8. 9.	9. 8. 22.	8. 9. 23.	24.	24.	10.	
30	E. 10. 22.	10. 23.	10. 23.	11. 23.	11.	12.	12.	12.			2.	2. 1.	30
	W. 2. 5. 4.	4. 5. 18.	4. 6. 18.	6.	20. 7.	20. 7.	9. 7. 20. 23.	9. 8. 22. 3.	9. 8. 23.	8.		10. 11.	
40	E. 22. 10.	10. 23. 22.	23. 10. 22.	11. 23.	11. 23.	12.	12.	12.		2.	2.	1. 2.	40
	W. 2. 4. 5. 18.	2. 4. 5. 18.	4. 6. 18.	6.	20. 22.	20. 22. 23.	22. 23. 20. 9.	9. 7. 23. 8.	9. 7. 8.	7. 8.	7. 8.	10. 11.	
50	E. 10. 20. 22.	20. 22. 10.	22.	23. 11.	23. 11.	12. 11.	12. 2.	2. 12.	2.	2.	2. 1.	2. 1. 7.	50
	W. 2. 5. 4. 18.	2. 4. 18. 5.	2. 4. 6. 20.	2. 4. 6. 20.	20. 22. 6.	20. 22. 23.	9. 7. 22. 23.	9. 7.	9. 7. 8.	7. 8. 9.	7. 8.	8. 11.	
60	E. 20. 10.	20. 22. 10.	22. 11.	11.	11.	2. 12. 11.	2. 12. 11.	2. 12.	2. 12.	2.	1. 2.	1. 2. 4. 7.	60
	W. 5. 18. 2. 6.	2. 4. 5. 6. 18.	20. 2. 4. 6.	20. 2. 4. 6. 22.	20. 2. 4. 6.	20. 4.	9.	9.	9. 7.	7. 9. 11.	7. 8. 11.	8. 11.	

TABLE IV.—*continued.*

Latitude South.	SIDEREAL TIME.												Latitude South.
Degrees.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	Degrees.
10	E. 1. 14. W. 11. 24.	2. 15. 3. 14. 24.	2. 15. 16. 24.	2. 15. 5. 4. 12.	17. 4. 12.	17. 6. 18. 13.	17. 6. 13. 2.	19. 17. 13. 2.	19. 17. 20. 2. 1.	19. 21. 20. 7. 2. 1. 14.	9. 21. 8. 22. 15. 17. 3. 14.	21. 23. 8. 17. 16. 15. 4.	10
20	E. 15. 14. 1. W. 11.	15. 16. 1. 3. 24.	16. 15. 3. 2. 24. 12.	17. 5. 2. 12.	17. 18. 4. 2. 12.	17. 18. 4. 2.	19. 6. 2. 13.	19. 2. 13.	19. 21. 20. 2. 1. 13.	21. 20. 1.	21. 9. 22. 4. 3. 14.	9. 23. 8. 15. 16. 4.	20
30	E. 15. 17. 1. 14. W. 11.	17. 15. 16. 1. 24.	17. 16. 3. 12. 24.	17. 5. 12. 24.	2. 19. 18. 24.	19. 18. 4. 2.	19. 6. 21. 2.	21. 2. 1. 13.	21. 20. 4. 1. 13.	21. 22. 20. 4. 13. 3. 14.	22. 4. 3. 14.	9. 23. 16. 5.	30
40	E. 17. 15. 14. W. 21. 11.	19. 17. 16. 1. 21. 12	19. 16. 3. 1. 21. 12.	19. 21. 5. 12. 24.	19. 21. 5. 24.	19. 21. 18. 24.	21. 6. 4. 1. 24.	21. 6. 1.	20. 6. 4. 1. 13.	20. 22. 4. 13. 3. 14.	23. 22. 24. 13. 3. 14. 5.	9. 23. 24. 5. 16. 13.	40
50	E. 14. W. 19. 21. 12.	19. 16. 14. 21. 12.	19. 16. 3. 21. 12.	21. 19. 3. 1. 24.	21. 19. 5. 24.	21. 18. 5. 1. 24.	21. 18. 5. 1. 24.	6. 24. 1. 3.	20. 6. 3.	22. 20. 6. 24. 13. 14. 3. 5.	24. 23. 22. 13. 5. 14.	23. 24. 13. 6. 5. 16.	50
60	E. 14. W. 19. 21. 12.	19. 14. 21. 12.	16. 14. 21.	1. 3. 16. 21.	1. 3. 5. 18. 21.	3. 5. 18. 1. 24.	5. 18. 3. 1. 24.	5. 6. 3. 24.	6. 20. 5. 3. 14.	6. 20. 22. 24. 5. 14.	6. 20. 22. 23. 24. 5. 14.	20. 22. 23. 24. 16. 6. 5. 13.	60

Latitude South.	SIDEREAL TIME.												Latitude South.
Degrees.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	Degrees.
10	E. 8. 23. W. 17. 5. 15. 16.	8. 17. 7.	10. 17. 6. 8. 18.	10. 24. 11. 19. 17. 8.	10. 24. 19. 8.	24. 19. 21. 8.	12. 19. 21. 20. 9.	12. 21. 9. 22.	13. 21. 22.	13. 10. 23.	13. 10.	 10. 24.	10
20	E. 23. 8. W. 16. 15. 6.	8. 15. 17.	24. 17. 6. 18. 8.	24. 10. 17. 8.	10. 11. 17. 8.	10. 19. 9.	10. 19. 9. 20.	13. 12. 10. 19. 21. 22.	13. 21. 10. 22.	13. 10. 21. 23.	 10. 23.	 11.	20
30	E. 9. W. 15. 16. 5.	24. 15. 6.	24. 15. 6. 18.	11. 24. 17.	8. 11. 17. 9.	10. 11. 17. 9.	10. 13. 17. 19. 9. 20.	13. 12. 19. 17. 10. 22.	13. 12. 19. 17. 10. 21.	 21. 10. 19. 23.	17. 21. 23.	15. 17. 11.	30
40	E. 9. 24. W. 16. 5. 6.	24. 9. 6. 15.	9. 24. 15. 6. 18.	13. 9. 15.	13. 11. 9. 17.	13. 11. 17. 9.	13. 10. 17. 20.	13. 12. 17. 10. 19. 22.	12. 17. 19. 22.	17. 12. 15. 19. 21. 23.	17. 15. 19. 21. 23. 11.	17. 15. 19. 21. 11.	40
50	E. 9. 24. W. 13. 5. 16. 6.	9. 6. 15. 18.	9. 13. 15. 18.	13. 9. 15.	13. 11. 9. 15.	11. 13. 15. 20.	11. 13. 15. 20.	11. 15. 17. 22.	15. 12. 17. 19. 22. 11.	15. 12. 17. 19. 23. 11.	17. 15. 12. 19. 21. 23. 11.	17. 15. 19. 21. 11. 23.	50
60	E. W. 16. 13. 6. 18.	9. 16. 13. 18.	9. 13. 18.	13. 15. 9.	13. 20. 15.	11. 15. 20.	11. 15. 20. 22.	15. 11. 22.	15. 11. 22.	15. 12. 23. 11.	12. 15. 23. 11.	15. 22. 19. 23.	60

TABLE V.—The Sun's Approximate Right Ascension diminished by Four Minutes, in order that Correction from Table VI. may be always added.

Day of the Month.	January.	February.	March.	April.	May.	June.	Day of the Month.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	
1	18 43	20 55	22 45	0 39	2 30	4 33	1
2	18 47	20 59	22 49	0 42	2 34	4 37	2
3	18 52	21 3	22 53	0 46	2 38	4 41	3
4	18 56	21 7	22 56	0 50	2 42	4 45	4
5	19 0	21 11	23 0	0 53	2 45	4 49	5
6	19 5	21 15	23 4	0 57	2 49	4 54	6
7	19 9	21 19	23 8	1 1	2 53	4 58	7
8	19 14	21 23	23 11	1 4	2 57	5 2	8
9	19 18	21 27	23 15	1 8	3 1	5 6	9
10	19 22	21 31	23 19	1 12	3 5	5 10	10
11	19 27	21 35	23 22	1 15	3 9	5 14	11
12	19 31	21 39	23 26	1 19	3 13	5 18	12
13	19 35	21 43	23 30	1 23	3 17	5 22	13
14	19 40	21 47	23 33	1 26	3 21	5 27	14
15	19 44	21 51	23 37	1 30	3 25	5 31	15
16	19 48	21 55	23 41	1 34	3 28	5 35	16
17	19 52	21 58	23 44	1 38	3 32	5 39	17
18	19 57	22 2	23 48	1 41	3 36	5 43	18
19	20 1	22 6	23 52	1 45	3 40	5 47	19
20	20 5	22 10	23 55	1 49	3 44	5 52	20
21	20 9	22 14	23 59	1 52	3 48	5 56	21
22	20 14	22 18	0 2	1 56	3 52	6 0	22
23	20 18	22 21	0 6	2 0	3 56	6 4	23
24	20 22	22 25	0 10	2 4	4 0	6 8	24
25	20 26	22 29	0 13	2 7	4 4	6 12	25
26	20 30	22 33	0 17	2 11	4 8	6 16	26
27	20 34	22 37	0 21	2 15	4 12	6 21	27
28	20 39	22 40	0 24	2 19	4 17	6 25	28
29	20 43	22 44	0 28	2 23	4 21	6 29	29
30	20 47	....	0 32	2 26	4 25	6 33	30
31	20 51	....	0 35	....	4 29	....	31

TABLE VI.—Correction to be added to the Approximate Right Ascension of Sun.

Apparent Time.	Long. 0°.	Long. 30° E.	Long. 60° E.	Long. 90° E.	Long. 120° E.	Long. 150° E.	Apparent Time.
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
A.M. 0 10	12 2	12 2	12 1	12 1	12 1	12 0	A.M. 0 10
A.M. 2 0	12 3	12 2	12 2	12 1	12 1	12 1	A.M. 2 0
A.M. 4 0	12 3	12 2	12 2	12 2	12 1	12 1	A.M. 4 0
A.M. 6 0	12 3	12 3	12 2	12 2	12 2	12 1	A.M. 6 0
A.M. 8 0	12 4	12 3	12 3	12 2	12 2	12 2	A.M. 8 0
A.M. 10 0	12 4	12 3	12 3	12 3	12 2	12 2	A.M. 10 0
A.M. 11 50	12 4	12 4	12 3	12 3	12 3	12 2	A.M. 11 50
P.M. 0 10	0 4	0 4	0 3	0 3	0 3	0 2	P.M. 0 10
P.M. 2 0	0 5	0 4	0 4	0 3	0 3	0 3	P.M. 2 0
P.M. 4 0	0 5	0 4	0 4	0 4	0 3	0 3	P.M. 4 0
P.M. 6 0	0 5	0 5	0 4	0 4	0 4	0 3	P.M. 6 0
P.M. 8 0	0 6	0 5	0 5	0 4	0 4	0 4	P.M. 8 0
P.M. 10 0	0 6	0 5	0 5	0 5	0 4	0 4	P.M. 10 0
P.M. 11 50	0 6	0 6	0 5	0 5	0 5	0 4	P.M. 11 50

TABLE V.—The Sun's Approximate Right Ascension diminished by Four Minutes, in order that Correction from Table VI. may be always added.

Day of the Month.	July.	August.	September.	October.	November.	December.	Day of the Month.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	
1	6 37	8 42	10 38	12 26	14 22	16 26	1
2	6 41	8 46	10 42	12 30	14 26	16 30	2
3	6 45	8 50	10 45	12 33	14 30	16 35	3
4	6 50	8 54	10 49	12 37	14 34	16 39	4
5	6 54	8 57	10 52	12 41	14 38	16 44	5
6	6 58	9 1	10 56	12 44	14 42	16 48	6
7	7 2	9 5	11 0	12 48	14 46	16 52	7
8	7 6	9 9	11 3	12 52	14 50	16 56	8
9	7 10	9 13	11 7	12 55	14 54	17 0	9
10	7 14	9 17	11 10	12 59	14 58	17 5	10
11	7 18	9 20	11 14	13 3	15 2	17 10	11
12	7 22	9 24	11 18	13 6	15 6	17 14	12
13	7 26	9 28	11 21	13 10	15 10	17 19	13
14	7 30	9 32	11 25	13 14	15 14	17 23	14
15	7 34	9 35	11 28	13 17	15 19	17 28	15
16	7 39	9 39	11 32	13 21	15 23	17 32	16
17	7 43	9 43	11 36	13 25	15 27	17 36	17
18	7 47	9 47	11 39	13 29	15 31	17 41	18
19	7 51	9 50	11 43	13 32	15 35	17 45	19
20	7 55	9 54	11 46	13 36	15 39	17 50	20
21	7 59	9 58	11 50	13 40	15 44	17 54	21
22	8 3	10 1	11 54	13 44	15 48	17 59	22
23	8 7	10 5	11 57	13 48	15 52	18 3	23
24	8 11	10 9	12 1	13 51	15 56	18 8	24
25	8 15	10 12	12 4	13 55	16 0	18 12	25
26	8 18	10 16	12 8	13 59	16 5	18 16	26
27	8 22	10 20	12 12	14 3	16 9	18 21	27
28	8 26	10 23	12 15	14 7	16 13	18 25	28
29	8 30	10 27	12 19	14 11	16 18	18 30	29
30	8 34	10 31	12 22	14 14	16 22	18 34	30
31	8 38	10 34	....	14 18	....	18 39	31

TABLE VI.—Correction to be added to the Approximate Right Ascension of Sun.

Apparent Time.	Long. 179° E.	Long. 150° W.	Long. 120° W.	Long. 90° W.	Long. 60° W.	Long. 30° W.	Apparent Time.
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
A.M. 0 10	12 0	12 4	12 4	12 3	12 3	12 3	A.M. 0 10
A.M. 2 0	12 0	12 4	12 4	12 4	12 3	12 3	A.M. 2 0
A.M. 4 0	12 1	12 5	12 4	12 4	12 4	12 3	A.M. 4 0
A.M. 6 0	12 1	12 5	12 5	12 4	12 4	12 4	A.M. 6 0
A.M. 8 0	12 1	12 5	12 5	12 5	12 4	12 4	A.M. 8 0
A.M. 10 0	12 2	12 6	12 5	12 5	12 5	12 4	A.M. 10 0
A.M. 11 50	12 2	12 6	12 6	12 5	12 5	12 5	A.M. 11 50
P.M. 0 10	0 2	0 6	0 6	0 5	0 5	0 5	P.M. 0 10
P.M. 2 0	0 2	0 6	0 6	0 6	0 5	0 5	P.M. 2 0
P.M. 4 0	0 3	0 7	0 6	0 6	0 6	0 5	P.M. 4 0
P.M. 6 0	0 3	0 7	0 7	0 6	0 6	0 6	P.M. 6 0
P.M. 8 0	0 3	0 7	0 7	0 7	0 6	0 6	P.M. 8 0
P.M. 10 0	0 4	0 8	0 7	0 7	0 7	0 6	P.M. 10 0
P.M. 11 50	0 4	0 8	0 8	0 7	0 7	0 7	P.M. 11 50

TABLE VII.—DECLINATION NORTH.

Hour Angle.	α Tauri (Aldebaran). No. 1. Right Ascension, 4h 28m.		α Aurigæ (Capella). No. 2. Right Ascension, 5h 7m.		α Orionis (Betelguese). No. 3. Right Ascension, 5h 48m.		α² Geminorum (Castor). No. 4. Right Ascension, 7h 26m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	16 14	8·2242	45 51	8·0848	7 23	8·2384	32 11	8·1695	0 4
11 52	16 14	8·4254	45 52	8·3859	7 23	8·5386	32 12	8·4706	0 8
11 48	16 15	8·7017	45 53	8·5620	7 24	8·7159	32 13	8·6468	0 12
11 44	16 17	8·8268	45 55	8·6866	7 24	8·8411	32 15	8·7719	0 16
11 40	16 18	8·9242	45 57	8·7834	7 25	8·9385	32 17	8·8691	0 20
11 36	16 20	9·0038	46 0	8·8633	7 26	9·0181	32 20	8·9485	0 24
11 32	16 22	9·0713	46 4	8·9303	7 27	9·0856	32 22	9·0158	0 28
11 28	16 24	9·1299	46 8	8·9885	7 28	9·1443	32 24	9·0743	0 32
11 24	16 27	9·1816	46 12	9·0398	7 29	9·1961	32 27	9·1259	0 36
11 20	16 30	9·2281	46 17	9·0856	7 30	9·2426	32 32	9·1721	0 40
11 16	16 33	9·2704	46 23	9·1263	7 31	9·2849	32 39	9·2140	0 44
11 12	16 36	9·3091	46 29	9·1654	7 33	9·3237	32 45	9·2523	0 48
11 8	16 40	9·3449	46 36	9·2000	7 35	9·3597	32 51	9·2877	0 52
11 4	16 44	9·3772	46 43	9·2321	7 37	9·3930	32 58	9·3206	0 56
11 0	16 48	9·4092	46 51	9·2631	7 40	9·4242	33 5	9·3513	1 0
10 56	16 53	9·4385	46 59	9·2913	7 42	9·4536	33 13	9·3800	1 4
10 52	16 58	9·4651	47 8	9·3180	7 44	9·4815	33 21	9·4072	1 8
10 48	17 3	9·4923	47 17	9·3432	7 46	9·5079	33 30	9·4229	1 12
10 44	17 8	9·5173	47 27	9·3670	7 49	9·5331	33 39	9·4573	1 16
10 40	17 14	9·5412	47 38	9·3897	7 52	9·5571	33 49	9·4806	1 20
10 36	17 21	9·5640	47 49	9·4113	7 55	9·5800	33 59	9·5029	1 24
10 32	17 29	9·5859	48 1	9·4318	8 0	9·6022	34 10	9·5241	1 28
10 28	17 36	9·6072	48 13	9·4515	8 3	9·6236	34 22	9·5446	1 32
10 24	17 43	9·6266	48 26	9·4704	8 6	9·6442	34 34	9·5643	1 36
10 20	17 51	9·6474	48 39	9·4885	8 9	9·6643	34 47	9·5833	1 40
10 16	17 59	9·6666	48 53	9·4960	8 13	9·6837	35 0	9·6016	1 44
10 12	18 8	9·6851	49 8	9·5229	8 17	9·7026	35 14	9·6193	1 48
10 8	18 18	9·7033	49 24	9·5390	8 22	9·7210	35 29	9·6364	1 52
10 4	18 28	9·7211	49 40	9·5547	8 26	9·7391	35 45	9·6531	1 56
10 0	18 38	9·7381	49 57	9·5699	8 32	9·7566	36 1	9·6693	2 0
9 56	18 49	9·7550	50 15	9·5846	8 37	9·7737	36 18	9·6851	2 4
9 52	19 1	9·7716	50 33	9·5989	8 43	9·7906	36 36	9·7005	2 8
9 48	19 13	9·7878	50 52	9·6127	8 49	9·8073	36 53	9·7155	2 12
9 44	19 25	9·8038	51 11	9·6262	8 56	9·8238	37 12	9·7302	2 16
9 40	19 38	9·8194	51 31	9·6392	9 1	9·8399	37 32	9·7445	2 20
9 36	19 51	9·8348	51 51	9·6521	9 8	9·8558	37 53	9·7586	2 24
9 32	20 4	9·8500	52 13	9·6644	9 15	9·8712	38 15	9·7723	2 28
9 28	20 17	9·8650	52 35	9·6765	9 22	9·8870	38 37	9·7857	2 32
9 24	20 31	9·8799	52 58	9·6882	9 30	9·9024	39 0	9·7989	2 36
9 20	20 48	9·8944	53 22	9·6996	9 38	9·9177	39 24	9·8118	2 40
9 16	21 5	9·9091	53 47	9·7108	9 47	9·9329	39 49	9·8246	2 44
9 12	21 23	9·9234	54 12	9·7216	9 56	9·9479	40 15	9·8370	2 48
9 8	*21 43*	*9·9379*	54 38	9·7322	10 6	9·9629	40 42	9·8493	2 52
9 4	*22 3*	*9·9618*	55 5	9·7425	10 15	9·9778	41 10	9·8613	2 56
9 0	*22 23*	*9·9659*	55 32	9·7528	10 26	9·9928	41 40	9·8733	3 0

TABLE VII.—DECLINATION NORTH.

Hour Angle.	α Tauri (Aldebaran). No. 1. Right Ascension, 4h 28m.		α Aurigæ (Capella). No. 2. Right Ascension, 5h 7m.		α Orionis (Betelguese). No. 3. Right Ascension, 5h 48m.		α² Geminorum (Castor). No. 4. Right Ascension, 7h 26m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	22 46	9·9801	56 1	9·7625	10 38	10·0077	42 12	9·8849	3 4
8 52	23 9	9·9939	56 30	9·7720	10 49	10·0226	42 43	9·8975	3 8
8 48	23 33	10·0079	57 0	9·7817	11 1	10·0375	43 15	9·9080	3 12
8 44	23 57	10·0218	57 30	9·7909	11 14	10·0525	43 49	9·9192	3 16
8 40	24 23	10·0357	58 2	9·8000	11 28	10·0676	44 24	9·9308	3 20
8 36	24 52	10·0495	58 34	9·8088	11 42	10·0826	45 0	9·9411	3 24
8 32	25 22	10·0631	59 7	9·8176	11 57	10·0979	45 37	9·9516	3 28
8 28	25 52	10·0771	59 42	9·8259	12 13	10·1132	46 16	9·9622	3 32
8 24	26 24	10·0910	60 18	9·8338	12 31	10·1285	46 57	9·9728	3 36
8 20	26 57	10·1050	60 54	9·8417	12 49	10·1441	47 40	9·9831	3 40
8 16	27 33	10·1188	61 31	9·8494	13 8	10·1598	48 23	9·9937	3 44
8 12	28 11	10·1328	62 8	9·8572	13 28	10·1756	49 8	10·0034	3 48
8 8	28 51	10·1467	62 46	9·8649	13 50	10·1917	49 55	10·0132	3 52
8 4	29 33	10·1607	63 25	9·8719	14 13	10·2080	50 43	10·0228	3 56
8 0	30 14	10·1751	64 6	9·8788	14 38	10·2246	51 32	10·0324	4 0
7 56	31 0	10·1893	64 48	9·8854	15 4	10·2413	52 22	10·0416	4 4
7 52	31 49	10·2036	65 30	9·8930	15 33	10·2584	53 16	10·0509	4 8
7 48	32 42	10·2179	66 13	9·8984	16 3	10·2756	54 12	10·0599	4 12
7 44	33 39	10·2324	66 57	9·9041	16 35	10·2936	55 9	10·0689	4 16
7 40	34 38	10·2468	67 42	9·9101	17 11	10·3118	56 7	10·0774	4 20
7 36	35 39	10·2613	68 27	9·9164	17 49	10·3304	57 8	10·0860	4 24
7 32	36 43	10·2758	69 13	9·9200	18 31	10·3494	58 10	10·0947	4 28
7 28	37 55	10·2907	70 0	9·9275	19 16	10·3693	59 14	10·1032	4 32
7 24	39 8	10·3048	70 49	9·9324	20 3	10·3891	60 20	10·1103	4 36
7 20	40 23	10·3210	71 38	9·9371	20 55	10·4095	61 29	10·1174	4 40
7 16	41 47	10·3356	72 28	9·9418	21 53	10·4307	62 39	10·1248	4 44
7 12	43 17	10·3501	73 18	9·9466	22 57	10·4530	63 51	10·1324	4 48
7 8	44 55	10·3654	74 9	9·9510	24 4	10·4743	65 5	10·1404	4 52
7 4	46 31	10·3801	75 1	9·9550	25 23	10·4988	66 21	10·1469	4 56
7 0	48 21	10·3941	75 54	9·9587	26 49	10·5233	67 38	10·1521	5 0
6 56	50 20	10·4073	76 47	9·9623	28 23	10·5472	68 58	10·1581	5 4
6 52	52 24	10·4225	77 41	9·9657	30 11	10·5722	70 20	10·1629	5 8
6 48	54 27	10·4365	78 35	9·9689	32 11	10·6024	71 43	10·1690	5 12
6 44	56 42	10·4518	79 30	9·9716	34 28	10·6286	73 8	10·1739	5 16
6 40	59 6	10·4628	80 26	9·9745	37 1	10·6582	74 34	10·1787	5 20
6 36	61 40	10·4748	81 22	9·9767	39 55	10·6879	76 3	10·1827	5 24
6 32	64 20	10·4865	82 18	9·9790	43 15	10·7179	77 32	10·1865	5 28
6 28	67 18	10·4972	83 15	9·9808	47 4	10·7479	79 2	10·1899	5 32
6 24	70 14	10·5022	84 12	9·9825	51 21	10·7772	80 34	10·1928	5 36
6 20	73 17	10·5151	85 10	9·9839	56 18	10·8043	82 7	10·1953	5 40
6 16	76 27	10·5226	86 8	9·9851	61 53	10·8314	83 40	10·1975	5 44
6 12	79 47	10·5275	87 6	9·9859	67 51	10·8539	85 15	10·1991	5 48
6 8	83 9	10·5314	88 4	9·9869	75 0	10·8759	86 50	10·2003	5 52
6 4	86 33	10·5336	89 2	9·9871	82 18	10·8857	88 25	10·2006	5 56
6 0	90 0	10·5359	90 0	9·9871	90 0	10·8875	90 0	10·2011	6 0

TABLE VII.—DECLINATION NORTH.

Hour Angle.	α Canis Minoris (Procyon). No. 5. Right Ascension, 7h 32m.		α Leonis (Regulus). No. 6. Right Ascension, 10h 1m.		α Ursæ Majoris (Dubhe). No. 7. Right Ascension, 10h 55m.		η Ursæ Majoris (Benetnach). No. 8. Right Ascension, 13h 42m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	5 34	8·2398	12 37	8·2313	62 29	7·9065	49 59	8·0501	0 4
11 52	5 34	8·5410	12 37	8·5325	62 30	8·2075	50 0	8·3512	0 8
11 48	5 34	8·7173	12 38	8·7088	62 31	8·3836	50 1	8·5273	0 12
11 44	5 35	8·8425	12 39	8·8340	62 32	8·5084	50 3	8·6522	0 16
11 40	5 35	8·9399	12 40	8·9314	62 34	8·6053	50 5	8·7492	0 20
11 36	5 36	9·0194	12 41	9·0109	62 36	8·6844	50 8	8·8284	0 24
11 32	5 36	9·0869	12 42	9·0774	62 39	8·7512	50 12	8·8854	0 28
11 28	5 37	9·1462	12 44	9·1370	62 42	8·8091	50 16	8·9525	0 32
11 24	5 38	9·1974	12 46	9·1889	62 46	8·8601	50 20	9·0047	0 36
11 20	5 39	9·2440	12 48	9·2354	62 50	8·9057	50 25	9·0505	0 40
11 16	5 40	9·2864	12 50	9·2777	62 55	8·9470	50 30	9·0921	0 44
11 12	5 41	9·3252	12 53	9·3164	63 0	8·9845	50 36	9·1301	0 48
11 8	5 42	9·3611	12 56	9·3522	63 5	9·0191	50 42	9·1650	0 52
11 4	5 44	9·3935	12 59	9·3855	63 11	9·0511	50 49	9·1973	0 56
11 0	5 46	9·4258	13 3	9·4167	63 17	9·0808	50 57	9·2274	1 0
10 56	5 47	9·4552	13 6	9·4460	63 24	9·1085	51 5	9·2555	1 4
10 52	5 49	9·4831	13 10	9·4738	63 31	9·1346	51 14	9·2820	1 8
10 48	5 51	9·5094	13 14	9·5001	63 39	9·1592	51 23	9·3070	1 12
10 44	5 53	9·5345	13 19	9·5252	63 47	9·1824	51 33	9·3307	1 16
10 40	5 55	9·5587	13 24	9·5492	63 55	9·2043	51 43	9·3532	1 20
10 36	5 57	9·5817	13 29	9·5721	64 4	9·2251	51 54	9·3745	1 24
10 32	6 0	9·6039	13 34	9·5942	64 13	9·2449	52 6	9·3948	1 28
10 28	6 3	9·6253	13 40	9·6156	64 23	9·2638	52 18	9·4143	1 32
10 24	6 6	9·6460	13 46	9·6360	64 33	9·2818	52 31	9·4329	1 36
10 20	6 10	9·6660	13 52	9·6559	64 44	9·2991	52 44	9·4508	1 40
10 16	6 13	9·6854	13 58	9·6751	64 55	9·3156	52 57	9·4681	1 44
10 12	6 16	9·7042	14 6	9·6939	65 6	9·3315	53 11	9·4848	1 48
10 8	6 20	9·7229	14 14	9·7122	65 18	9·3478	53 26	9·5007	1 52
10 4	6 24	9·7409	14 22	9·7301	65 30	9·3615	53 42	9·5161	1 56
10 0	6 28	9·7585	14 30	9·7473	65 43	9·3755	53 59	9·5308	2 0
9 56	6 31	9·7757	14 38	9·7644	65 56	9·3891	54 16	9·5451	2 4
9 52	6 35	9·7926	14 47	9·7812	66 10	9·4022	54 34	9·5590	2 8
9 48	6 39	9·8094	14 56	9·7975	66 24	9·4149	54 52	9·5726	2 12
9 44	6 45	9·8258	15 6	9·8137	66 39	9·4272	55 10	9·5857	2 16
9 40	6 49	9·8420	15 17	9·8296	66 54	9·4391	55 29	9·5984	2 20
9 36	6 56	9·8581	15 28	9·8453	67 9	9·4506	55 48	9·6110	2 24
9 32	7 0	9·8738	15 39	9·8607	67 25	9·4616	56 8	9·6231	2 28
9 28	7 4	9·8895	15 51	9·8759	67 41	9·4724	56 29	9·6348	2 32
9 24	7 8	9·9050	16 3	9·8911	67 58	9·4828	56 52	9·6460	2 36
9 20	7 14	9·9203	16 16	9·9061	68 15	9·4929	57 15	9·6569	2 40
9 16	7 23	9·9356	16 30	9·9209	68 32	9·5027	57 38	9·6677	2 44
9 12	7 29	9·5507	16 44	9·9357	68 50	9·5120	58 2	9·6782	2 48
9 8	7 35	9·9659	17 0	9·9504	69 8	9·5212	58 27	9·6875	2 52
9 4	7 42	9·9800	17 16	9·9648	69 27	9·5300	58 52	9·6983	2 56
9 0	7 51	9·9950	17 32	9·9793	69 47	9·5387	59 18	9·7080	3 0

TABLE VII.—DECLINATION NORTH.

Hour Angle.	α Canis Minoris (Procyon). No. 5. Right Ascension, 7h 32m.		α Leonis (Regulus). No. 2. Right Ascension, 10h 1m.		α Ursæ Majoris (Dubhe). No. 7. Right Ascension, 10h 55m.		η Ursæ Majoris (Benetnach). No. 8. Right Ascension, 13h 42m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	7 58	10·0110	17 51	9·9938	70 7	9·5466	59 45	9·7174	3 4
8 52	8 9	10·0259	18 10	10·0082	70 28	9·5543	60 12	9·7268	3 8
8 48	8 19	10·0410	18 29	10·0227	70 49	9·5621	60 40	9·7356	3 12
8 44	8 27	10·0561	18 49	10·0370	71 9	9·5706	61 9	9·7441	3 16
8 40	8 37	10·0713	19 11	10·0514	71 30	9·5777	61 39	9·7526	3 20
8 36	8 48	10·0864	19 34	10·0658	71 51	9·5852	62 9	9·7611	3 24
8 32	8 59	10·1018	19 58	10·0804	72 13	9·5928	62 40	9·7692	3 28
8 28	9 11	10·1172	20 23	10·0949	72 35	9·5995	63 12	9·7770	3 32
8 24	9 24	10·1328	20 49	10·1095	72 58	9·6053	63 44	9·7847	3 36
8 20	9 38	10·1485	21 17	10·1244	73 21	9·6113	64 17	9·7922	3 40
8 16	9 53	10·1645	21 46	10·1391	73 45	9·6175	64 51	9·7994	3 44
8 12	10 8	10·1806	22 18	10·1540	74 10	9·6236	65 26	9·8063	3 48
8 8	10 26	10·1969	22 50	10·1689	74 34	9·6293	66 1	9·8130	3 52
8 4	10 44	10·2125	23 26	10·1840	74 59	9·6348	66 37	9·8197	3 56
8 0	11 2	10·2305	24 3	10·1994	75 24	9·6402	67 13	9·8264	4 0
7 56	11 21	10·2476	24 43	10·2147	75 50	9·6454	67 50	9·8327	4 4
7 52	11 43	10·2651	25 26	10·2303	76 16	9·6503	68 28	9·8387	4 8
7 48	12 6	10·2830	26 11	10·2460	76 42	9·6548	69 8	9·8445	4 12
7 44	12 31	10·3013	27 0	10·2618	77 8	9·6592	69 48	9·8501	4 16
7 40	12 58	10·3201	27 52	10·2779	77 35	9·6636	70 28	9·8555	4 20
7 36	13 26	10·3393	28 48	10·2938	78 2	9·6680	71 9	9·8608	4 24
7 32	14 0	10·3589	29 48	10·3106	78 29	9·6722	71 50	9·8657	4 28
7 28	14 36	10·3797	30 51	10·3273	78 57	9·6760	72 32	9·8707	4 32
7 24	15 14	10·4003	32 4	10·3447	79 25	9·6795	73 15	9·8754	4 36
7 20	15 56	10·4218	33 18	10·3624	79 53	9·6830	73 58	9·8798	4 40
7 16	16 37	10·4443	34 33	10·3806	80 21	9·6863	74 42	9·8840	4 44
7 12	17 33	10·4676	35 49	10·3973	80 51	9·6895	75 27	9·8881	4 48
7 8	18 29	10·4917	37 17	10·4140	81 20	9·6925	76 12	9·8919	4 52
7 4	19 31	10·5168	38 58	10·4318	81 49	9·6952	76 58	9·8955	4 56
7 0	20 39	10·5429	40 42	10·4513	82 19	9·6978	77 44	9·8990	5 0
6 56	21 57	10·5703	42 33	10·4690	82 49	9·7003	78 31	9·9022	5 4
6 52	23 23	10·5987	44 35	10·4868	83 19	9·7028	79 18	9·9052	5 8
6 48	25 5	10·6292	46 56	10·5064	83 49	9·7048	80 6	9·9080	5 12
6 44	27 2	10·6608	49 26	10·5283	84 19	9·7067	80 54	9·9105	5 16
6 40	29 17	10·6937	52 5	10·5447	84 49	9·7085	81 42	9·9128	5 20
6 36	31 55	10·7285	54 54	10·5596	85 20	9·7099	82 31	9·9150	5 24
6 32	34 58	10·7518	57 58	10·5761	85 51	9·7112	83 20	9·9169	5 28
6 28	38 38	10·7862	61 16	10·5915	86 22	9·7125	84 9	9·9186	5 32
6 24	43 0	10·8222	64 50	10·6060	86 53	9·7138	84 59	9 9201	5 36
6 20	48 13	10·8567	68 36	10·6189	87 24	9·7147	85 49	9·9213	5 40
6 16	54 24	10·8894	72 37	10·6298	87 55	9·7160	86 39	9·9224	5 44
6 12	61 46	10·9175	76 47	10·6385	88 26	9·7162	87 29	9·9231	5 48
6 8	61 19	10·9398	80 37	10·6461	88 57	9·7165	88 19	9·9236	5 52
6 4	79 43	10·9534	85 30	10·6514	89 29	9·7167	89 10	9·9239	5 56
6 0	90 0	11·0112	90 0	10·6501	90 0	9·7168	90 0	9·9241	6 0

Table VII.—Declination North.

Hour Angle.	α Boötis (Arcturus). No. 9. Right Ascension, 14h 10m.		α Lyræ (Vega). No. 10. Right Ascension, 18h 32m.		α Aquilæ (Altair). No. 11. Right Ascension, 19h 44m.		α Pegasi (Markab). No. 12. Right Ascension, 22h 58m.		Hour Angle.
	Arc I.	Log. I	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	19 53	8·2159	38 40	8·1344	8 30	8·2371	14 28	8·2283	0 4
11 52	19 53	8·5171	38 41	8·4356	8 30	8·5383	14 28	8·5294	0 8
11 48	19 54	8·6934	38 42	8·6117	8 31	8·7146	14 29	8·7057	0 12
11 44	19 55	8·8185	38 44	8·7367	8 31	8·8398	14 30	8·8409	0 16
11 40	19 57	8·9165	38 46	8·8339	8 32	8·9372	14 31	8·9283	0 20
11 36	19 59	8·9954	38 49	8·9132	8 33	9·0168	14 33	9·0078	0 24
11 32	20 1	9·0628	38 52	8·9803	8 34	9·0843	14 34	9·0743	0 28
11 28	20 4	9·1204	38 56	9·0386	8 35	9·1430	14 36	9·1338	0 32
11 24	20 7	9·1722	39 1	9·0901	8 36	9·1948	14 38	9·1857	0 36
11 20	20 10	9·2186	39 6	9·1362	8 37	9·2413	14 40	9·2322	0 40
11 16	20 14	9·2611	39 11	9·1780	8 39	9·2837	14 43	9·2745	0 44
11 12	20 18	9·3995	39 17	9·2162	8 41	9·3225	14 46	9·3132	0 48
11 8	20 22	9·3352	39 24	9·2514	8 43	9·3584	14 50	9·3490	0 52
11 4	20 27	9·3684	39 31	9·2841	8 45	9·3917	14 54	9·3821	0 56
11 0	20 32	9·3998	39 39	9·3146	8 48	9·4230	14 58	9·4133	1 0
10 56	20 37	9·4277	39 47	9·3431	8 50	9·4524	15 2	9·4426	1 4
10 52	20 43	9·4553	39 56	9·3701	8 53	9·4803	15 6	9·4693	1 8
10 48	20 50	9·4813	40 5	9·3956	8 56	9·5066	15 11	9·4965	1 12
10 44	20 56	9·5071	40 15	9·4198	8 59	9·5318	15 16	9·5216	1 16
10 40	21 3	9·5309	40 25	9·4428	9 2	9·5559	15 21	9·5454	1 20
10 36	21 11	9·5535	40 36	9·4646	9 6	9·5787	15 27	9·5683	1 24
10 32	21 21	9·5753	40 47	9·4855	9 10	9·6010	15 33	9·5904	1 28
10 28	21 30	9·5957	40 59	9·5056	9 14	9·6224	15 39	9·6116	1 32
10 24	21 39	9·6167	41 13	9·5249	9 18	9·6428	15 46	9·6319	1 36
10 20	21 47	9·6364	41 27	9·5435	9 22	9·6629	15 53	9·6519	1 40
10 16	21 56	9·6524	41 41	9·5614	9 26	9·6823	16 1	9·6709	1 44
10 12	22 5	9·6740	41 56	9·5788	9 31	9·7012	16 9	9·6897	1 48
10 8	22 15	9·6875	42 11	9·5955	9 36	9·7196	16 18	9·7079	1 52
10 4	22 26	9·7094	42 27	9·6117	9 41	9·7377	16 27	9·7257	1 56
10 0	22 39	9·7264	42 44	9·6274	9 47	9·7551	16 36	9·7429	2 0
9 56	22 52	9·7432	43 1	9·6427	9 54	9·7722	16 46	9·7600	2 4
9 52	23 5	9·7595	43 19	9·6575	10 0	9·7891	16 56	9·7765	2 8
9 48	23 18	9·7755	43 39	9·6720	10 6	9·8057	17 6	9·7928	2 12
9 44	23 33	9·7913	43 59	9·6861	10 14	9·8215	17 17	9·8090	2 16
9 40	23 49	9·8066	44 20	9·6998	10 21	9·8381	17 27	9·8247	2 20
9 36	24 4	9·8218	44 41	9·7132	10 28	9·8540	17 39	9·8403	2 24
9 32	24 21	9·8367	45 3	9·7262	10 36	9·8696	17 53	9·8556	2 28
9 28	24 39	9·8514	45 26	9·7389	10 45	9·8851	18 7	9·8707	2 32
9 24	24 57	9·8658	45 50	9·7514	10 53	9·9005	18 21	9·8857	2 36
9 20	25 16	9·8799	46 15	9·7635	11 3	9·9157	18 36	9·9006	2 40
9 16	25 36	9·8938	46 41	9·7755	11 12	9·9309	18 52	9·9151	2 44
9 12	25 56	9·9059	47 7	9·7873	11 23	9·9458	19 8	9·9298	2 48
9 8	26 19	9·9219	47 34	9·7989	11 33	9·9608	19 26	9·9444	2 52
9 4	26 42	9·9356	48 2	9·8101	11 44	9·9751	19 44	9·9586	2 56
9 0	27 5	9·9592	48 32	9·8210	11 54	9·9905	20 3	9·9729	3 0

TABLE VII.—DECLINATION NORTH.

Hour Angle.	α Boötis (Arcturus). No. 9. Right Ascension, 14h 10m.		α Lyræ (Vega). No. 10. Right Ascension, 18h 32m.		α Aquilæ (Altair). No. 11. Right Ascension, 19h 44m.		α Pegasi (Markab). No. 12. Right Ascension, 22h 58m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	27 31	9·9634	49 2	9·8319	12 8	10·0054	20 23	9·9865	3 4
8 52	27 58	9·9765	49 33	9·8424	12 22	10·0201	20 44	10·0012	3 8
8 48	28 25	9·9897	50 6	9·8528	12 36	10·0350	21 5	10·0156	3 12
8 44	28 53	10·0029	50 39	9·8629	12 50	10·0498	21 27	10·0297	3 16
8 40	29 23	10·0161	51 13	9·8728	13 5	10·0648	21 52	10·0438	3 20
8 36	29 55	10·0293	51 49	9·8827	13 21	10·0797	22 18	10·0579	3 24
8 32	30 27	10·0425	52 26	9·8923	13 38	10·0948	22 45	10·0723	3 28
8 28	31 1	10·0556	53 4	9·9017	13 56	10·1100	23 13	10·0863	3 32
8 24	31 37	10·0686	53 42	9·9110	14 16	10·1241	23 42	10·1006	3 36
8 20	32 15	10·0817	54 22	9·9202	14 36	10·1405	24 13	10·1151	3 40
8 16	32 54	10·0948	55 3	9·9291	14 58	10·1560	24 46	10·1293	3 44
8 12	33 36	10·1077	55 46	9·9378	15 21	10·1717	25 21	10·1435	3 48
8 8	34 21	10·1211	56 30	9·9463	15 45	10·1875	25 57	10·1578	3 52
8 4	35 7	10·1341	57 15	9·9547	16 11	10·2036	26 36	10·1725	3 56
8 0	35 54	10·1468	58 0	9·9628	16 38	10·2200	27 18	10·1873	4 0
7 56	36 42	10·1596	58 47	9·9708	17 7	10·2365	28 2	10·2022	4 4
7 52	37 35	10·1725	59 35	9·9785	17 43	10·2534	28 50	10·2168	4 8
7 48	38 34	10·1856	60 26	9·9860	18 18	10·2704	29 37	10·2319	4 12
7 44	39 35	10·1985	61 18	9·9933	18 54	10·2878	30 29	10·2471	4 16
7 40	40 37	10·2114	62 10	10·0005	19 31	10·3056	31 23	10·2622	4 20
7 36	41 39	10·2244	63 3	10·0076	20 10	10·3238	32 24	10·2777	4 24
7 32	42 45	10·2368	63 58	10·0144	20 50	10·3424	33 27	10·2933	4 28
7 28	43 55	10·2497	64 55	10·0209	21 43	10·3618	34 34	10·3092	4 32
7 24	45 17	10·2626	65 53	10·0272	22 38	10·3809	35 45	10·3251	4 36
7 20	46 44	10·2760	66 52	10·0332	23 38	10·4004	37 2	10·3414	4 40
7 16	48 5	10·2874	67 52	10·0391	24 41	10·4209	38 24	10·3576	4 44
7 12	49 30	10·3000	68 53	10·0448	25 48	10·4425	39 51	10·3734	4 48
7 8	51 7	10·3130	69 56	10·0502	27 0	10·4638	41 31	10·3899	4 52
7 4	52 45	10·3246	71 0	10·0553	28 22	10·4857	43 7	10·4057	4 56
7 0	54 25	10·3361	72 5	10·0601	29 59	10·5093	44 54	10·4219	5 0
6 56	56 11	10·3471	73 11	10·0646	31 49	10·5315	46 53	10·4378	5 4
6 52	58 8	10·3576	74 18	10·0689	33 41	10·5561	48 59	10·4546	5 8
6 48	60 7	10·3693	75 26	10·0731	35 41	10·5820	51 7	10·4699	5 12
6 44	62 2	10·3832	76 35	10·0769	37 45	10·6066	53 34	10·4870	5 16
6 40	64 22	10·3918	77 45	10·0812	40 25	10·6338	56 6	10·4992	5 20
6 36	66 38	10·4009	78 56	10·0833	43 39	10·6595	58 45	10·5149	5 24
6 32	68 57	10·4090	80 7	10·0861	47 2	10·6857	61 38	10·5287	5 28
6 28	71 22	10·4163	81 20	10·0886	50 48	10·7116	64 41	10·5414	5 32
6 24	73 52	10·4230	82 33	10·0907	55 2	10·7366	67 55	10·5529	5 36
6 20	76 26	10·4288	83 47	10·0926	59 45	10·7602	71 20	10·5633	5 40
6 16	79 7	10·4357	85 1	10·0942	64 59	10·7816	74 51	10·5723	5 44
6 12	81 47	10·4384	86 16	10·0953	70 42	10·7998	78 30	10·5792	5 48
6 8	84 30	10·4399	87 30	10·0959	76 51	10·8147	82 18	10·5844	5 52
6 4	87 14	10·4415	88 45	10·0964	83 20	10·8230	86 8	10·5875	5 56
6 0	90 0	10·4417	90 0	10·0968	90 0	10·8255	90 0	10·5884	6 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	α Eridani (Achernar). No. 13. Right Ascension, 1h 33m.		β Orionis (Rigel). No. 14. Right Ascension, 5h 8m.		α Argûs (Canopus). No. 15. Right Ascension, 6h 21m.		α Canis Majoris (Sirius). No. 16. Right Ascension, 6h 39m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	57 55	7·9671	8 22	8·2372	52 37	8·0246	16 32	8·2235	0 4
11 52	57 56	8·2681	8 22	8·5384	52 38	8·3257	16 32	8·5247	0 8
11 48	57 57	8·4442	8 23	8·7147	52 39	8·5017	16 33	8·7010	0 12
11 44	57 59	8·5690	8 23	8·8399	52 41	8·6266	16 34	8·8261	0 16
11 40	58 1	8·6660	8 24	8·9373	52 43	8·7236	16 35	8·9235	0 20
11 36	58 3	8·7451	8 25	9·0169	52 46	8·8027	16 37	9·0031	0 24
11 32	58 6	8·8120	8 26	9·0844	52 50	8·8596	16 39	9·0706	0 28
11 28	58 10	8·8700	8 27	9·1431	52 54	8·9367	16 41	9·1291	0 32
11 24	58 14	8·9211	8 28	9·1949	52 58	8·9988	16 44	9·1809	0 36
11 20	58 19	8·9669	8 29	9·2415	52 43	9·0246	16 47	9·2274	0 40
11 16	58 24	9·0083	8 31	9·2839	53 8	9·0661	16 50	9·2697	0 44
11 12	58 29	9·0458	8 33	9·3227	53 14	9·1041	16 53	9·3084	0 48
11 8	58 35	9·0804	8 35	9·3586	53 20	9·1389	16 57	9·3442	0 52
11 4	58 41	9·1125	8 37	9·3919	53 27	9·1712	17 1	9·3775	0 56
11 0	58 48	9·1424	8 39	9·4232	53 34	9·2012	17 5	9·4085	1 0
10 56	58 56	9·1702	8 41	9·4526	53 42	9·2293	17 10	9·4378	1 4
10 52	59 4	9·1965	8 44	9·4805	53 51	9·2557	17 15	9·4644	1 8
10 48	59 12	9·2212	8 47	9·5066	54 0	9·2806	17 20	9·4916	1 12
10 44	59 21	9·2446	8 50	9·5320	54 10	9·3042	17 25	9·5166	1 16
10 40	59 30	9·2666	8 53	9·5561	54 20	9·3266	17 31	9·5405	1 20
10 36	59 40	9·2876	8 57	9·5789	54 31	9·3478	17 38	9·5633	1 24
10 32	59 50	9·3076	9 1	9·6012	54 42	9·3680	17 45	9·5852	1 28
10 28	60 1	9·3267	9 5	9·6226	54 54	9·3874	17 53	9·6065	1 32
10 24	60 12	9·3449	9 9	9·6431	55 7	9·4059	18 0	9·6258	1 36
10 20	60 24	9·3624	9 13	9·6632	55 19	9·4237	18 8	9·6466	1 40
10 16	60 36	9·3792	9 17	9·6826	55 32	9·4409	18 16	9·6658	1 44
10 12	60 49	9·3953	9 22	9·7015	55 45	9·4575	18 25	9·6843	1 48
10 8	61 2	9·4008	9 27	9·7199	55 59	9·4733	18 35	9·7025	1 52
10 4	61 16	9·4258	9 32	9·7380	56 15	9·4886	18 45	9·7203	1 56
10 0	61 30	9·4401	9 38	9·7554	56 31	9·5032	18 55	9·7373	2 0
9 56	61 45	9·4539	9 45	9·7725	56 48	9·5173	19 6	9·7541	2 4
9 52	62 0	9·4673	9 51	9·7894	57 5	9·5310	19 18	9·7708	2 8
9 48	62 16	9·4803	9 57	9·8065	57 22	9·5444	19 30	9·7869	2 12
9 44	62 32	9·4929	10 5	9·8218	57 40	9·5573	19 42	9·8029	2 16
9 40	62 49	9·5049	10 12	9·8384	57 58	9·5698	19 55	9·8185	2 20
9 36	63 6	9·5168	10 19	9·8543	58 16	9·5822	20 8	9·8339	2 24
9 32	63 24	9·5282	10 27	9·8699	58 35	9·5941	20 23	9·8490	2 28
9 28	63 43	9·5392	10 36	9·8854	58 55	9·6056	20 38	9·8640	2 32
9 24	64 2	9·5499	10 44	9·9008	59 17	9·6166	20 54	9·8789	2 36
9 20	64 21	9·5602	10 53	9·9160	59 39	9·6273	21 21	9·8933	2 40
9 16	64 41	9·5704	11 2	9·9313	60 1	9·6379	21 28	9·9081	2 44
9 12	65 1	9·5801	11 13	9·9461	60 24	9·6481	21 47	9·9223	2 48
9 8	65 22	9·5897	11 23	9·9611	60 48	9·6571	22 7	9·9368	2 52
9 4	65 43	9·5988	11 34	9·9750	61 12	9·6676	22 27	9·9507	2 56
9 0	66 5	9·6077	11 44	9·9908	61 37	9·6770	22 47	9·9648	3 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	α Eridani (Achernar). No. 13. Right Ascension, 1h 33m.		β Orionis (Rigel). No. 14. Right Ascension, 5h 8m.		α Argûs (Canopus). No. 15. Right Ascension, 6h 21m.		α Canis Majoris (Sirius). No. 16. Right Ascension, 6h 39m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	66 28	9·6164	11 57	10·0056	62 3	9·6854	23 9	9·9789	3 4
8 52	66 51	9·6249	12 11	10·0203	62 31	9·6946	23 31	9·9927	3 8
8 48	67 15	9·6331	12 25	10·0252	62 57	9·7032	23 56	10·0066	3 12
8 44	67 39	9·6409	12 39	10·0500	63 24	9·7115	24 20	10·0205	3 16
8 40	68 3	9·6486	12 54	10·0650	63 52	9·7198	24 46	10·0344	3 20
8 36	68 28	9·6563	13 10	10·0799	64 20	9·7281	25 15	10·0481	3 24
8 32	68 53	9·6637	13 26	10·0950	64 49	9·7360	25 45	10·0617	3 28
8 28	69 19	9·6707	13 44	10·1105	65 19	9·7436	26 16	10·0756	3 32
8 24	69 46	9·6775	14 4	10·1245	65 49	9·7511	26 48	10·0895	3 36
8 20	70 13	9·6841	14 24	10·1409	66 20	9·7583	27 21	10·1034	3 40
8 16	70 41	9·6906	14 46	10·1564	66 52	9·7652	27 57	10·1173	3 44
8 12	71 9	9·6969	15 9	10·1721	67 25	9·7718	28 35	10·1311	3 48
8 8	71 37	9·7029	15 33	10·1880	67 58	9·7782	29 15	10·1450	3 52
8 4	72 6	9·7087	15 59	10·2041	68 32	9·7846	29 57	10·1588	3 56
8 0	72 36	9·7144	16 26	10·2205	69 6	9·7910	30 41	10·1732	4 0
7 56	73 6	9·7197	16 54	10·2370	69 40	9·7970	31 27	10·1873	4 4
7 52	73 36	9·7248	17 30	10·2540	70 15	9·8027	32 16	10·2015	4 8
7 48	74 7	9·7301	18 4	10·2710	70 52	9·8072	33 9	10·2157	4 12
7 44	74 38	9·7351	18 40	10·2885	71 29	9·8135	34 6	10·2301	4 16
7 40	75 10	9·7398	19 17	10·3063	72 5	9·8186	35 5	10·2444	4 20
7 36	75 42	9·7442	19 56	10·3245	72 42	9·8237	36 6	10·2588	4 24
7 32	76 14	9·7488	20 35	10·3432	73 19	9·8283	37 14	10·2730	4 28
7 28	76 47	9·7530	21 25	10·3627	73 57	9·8330	38 27	10·2877	4 32
7 24	77 20	9·7567	22 23	10·3819	74 36	9·8374	39 37	10·3024	4 36
7 20	77 54	9·7603	23 22	10·4014	75 15	9·8415	40 51	10·3176	4 40
7 16	78 28	9·7639	24 25	10·4225	75 55	9·8455	42 19	10·3320	4 44
7 12	79 2	9·7674	25 32	10·4436	76 36	9·8494	43 47	10·3462	4 48
7 8	79 37	9·7707	26 42	10·4649	77 17	9·8530	45 17	10·3613	4 52
7 4	80 12	9·7737	28 2	10·4871	77 59	9·8564	46 57	10·3758	4 56
7 0	80 47	9·7765	29 38	10·5109	78 41	9·8597	48 53	10·3896	5 0
6 56	81 22	9·7791	31 27	10·5332	79 25	9·8627	50 51	10·4025	5 4
6 52	81 58	9·7816	33 18	10·5581	80 9	9·8655	52 55	10·4174	5 8
6 48	82 34	9·7839	35 17	10·5842	80 54	9·8681	54 58	10·4312	5 12
6 44	83 10	9·7860	37 21	10·6091	81 39	9·8703	57 12	10·4462	5 16
6 40	83 47	9·7880	40 0	10·6365	82 24	9·8725	59 36	10·4569	5 20
6 36	84 24	9·7898	43 13	10·6625	83 10	9·8746	62 10	10·4687	5 24
6 32	85 1	9·7914	46 37	10·6889	83 55	9·8764	64 50	10·4800	5 28
6 28	85 38	9·7928	50 23	10·7155	84 40	9·8780	67 38	10·4905	5 32
6 24	86 15	9·7939	54 37	10·7410	85 26	9·8794	70 34	10·4997	5 36
6 20	86 52	9·7949	59 22	10·7651	86 12	9·8805	73 36	10·5078	5 40
6 16	87 30	9·7958	64 38	10·7870	86 57	9·8816	76 46	10·5152	5 44
6 12	88 7	9·7964	70 25	10·8057	87 43	9·8822	79 58	10·5200	5 48
6 8	88 45	9·7970	76 39	10·8207	88 28	9·8826	83 17	10·5232	5 52
6 4	89 22	9·7972	83 14	10·8280	89 13	9·8829	86 37	10·5254	5 56
6 0	90 0	9·7972	90 0	10·8325	90 0	9·8831	90 0	10·5275	6 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	β Argûs. No. 17. Right Ascension, 9h 12m.		α Hydræ (Alphard). No. 18. Right Ascension, 9h 21m.		α1 Crucis (Foot of the Cross). No. 19. Right Ascension, 12h 19m.		α Virginis (Spica). No. 20. Right Ascension, 13h 18m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	69 10	7·7927	8 4	8·2376	62 21	7·9083	10 27	8·2346	0 4
11 52	69 11	8·0938	8 4	8·5388	62 22	8·2093	10 27	8·5356	0 8
11 48	69 12	8·2699	8 5	8·7151	62 23	8·3854	10 28	8·7121	0 12
11 44	69 13	8·3947	8 5	8·8403	62 24	8·5102	10 28	8·8373	0 16
11 40	69 14	8·4916	8 6	8·9377	62 26	8·6071	10 29	8·9347	0 20
11 36	69 16	8·5705	8 7	9·0173	62 28	8·6860	10 30	9·0143	0 24
11 32	69 18	8·6373	8 8	9·0848	62 31	8·7530	10 31	9·0818	0 28
11 28	69 21	8·6951	8 9	9·1435	62 34	8·8109	10 33	9·1404	0 32
11 24	69 24	8·7460	8 10	9·1954	62 38	8·8619	10 35	9·1923	0 36
11 20	69 27	8·7815	8 11	9·2419	62 42	8·9075	10 37	9·2389	0 40
11 16	69 31	8·8327	8 13	9·2843	62 47	8·9488	10 39	9·2812	0 44
11 12	69 35	8·8701	8 15	9·3231	62 52	8·9863	10 41	9·3200	0 48
11 8	69 39	8·9045	8 16	9·3590	62 57	9·0210	10 44	9·3558	0 52
11 4	69 44	8·9353	8 17	9·3923	63 3	9·0530	10 47	9·3892	0 56
11 0	69 49	8·9659	8 19	9·4236	63 9	9·0827	10 50	9·4204	1 0
10 56	69 54	8·9935	8 21	9·4530	63 16	9·1104	10 53	9·4497	1 4
10 52	70 0	9·0194	8 24	9·4809	63 23	9·1365	10 56	9·4774	1 8
10 48	70 6	9·0437	8 26	9·5071	63 31	9·1611	10 59	9·5038	1 12
10 44	70 12	9·0667	8 30	9·5323	63 39	9·1843	11 3	9·5287	1 16
10 40	70 19	9·0884	8 34	9·5564	63 47	9·2061	11 7	9·5529	1 20
10 36	70 26	9·1090	8 38	9·5792	63 56	9·2270	11 11	9·5758	1 24
10 32	70 33	9·1285	8 42	9·6015	64 5	9·2469	11 16	9·5979	1 28
10 28	70 41	9·1472	8 46	9·6229	64 15	9·2657	11 21	9·6192	1 32
10 24	70 50	9·1649	8 50	9·6434	64 25	9·2837	11 26	9·6398	1 36
10 20	70 58	9·1819	8 54	9·6635	64 36	9·3011	11 31	9·6598	1 40
10 16	71 7	9·1982	8 58	9·6829	64 47	9·3176	11 36	9·6790	1 44
10 12	71 16	9·2139	9 3	9·7018	64 58	9·3335	11 42	9·6979	1 48
10 8	71 26	9·2289	9 8	9·7202	65 10	9·3498	11 48	9·7161	1 52
10 4	71 36	9·2433	9 14	9·7383	65 22	9·3635	11 55	9·7341	1 56
10 0	71 46	9·2569	9 20	9·7557	65 35	9·3775	12 2	9·7517	2 0
9 56	71 56	9·2701	9 24	9·7728	65 48	9·3911	12 9	9·7688	2 4
9 52	72 7	9·2829	9 30	9·7897	66 2	9·4042	12 17	9·7856	2 8
9 48	72 18	9·2955	9 36	9·8064	66 16	9·4169	12 25	9·8031	2 12
9 44	72 29	9·3076	9 42	9·8227	66 31	9·4292	12 32	9·8183	2 16
9 40	72 41	9·3191	9 49	9·8388	66 46	9·4411	12 41	9·8342	2 20
9 36	72 53	9·3301	9 56	9·8547	67 1	9·4526	12 50	9·8500	2 24
9 32	73 6	9·3407	10 4	9·8704	67 17	9·4636	13 0	9·8655	2 28
9 28	73 19	9·3510	10 12	9·8859	67 33	9·4744	13 10	9·8809	2 32
9 24	73 52	9·3611	10 20	9·9013	67 50	9·4848	13 21	9·8962	2 36
9 20	73 45	9·3708	10 30	9·9165	68 7	9·4949	13 32	9·9108	2 40
9 16	73 58	9·3802	10 39	9·9317	68 24	9·5047	13 44	9·9257	2 44
9 12	74 12	9·3892	10 49	9·9466	68 42	9·5140	13 56	9·9410	2 48
9 8	74 26	9·3980	10 59	9·9615	69 0	9·5232	14 8	9·9564	2 52
9 4	74 41	9·4064	11 9	9·9764	69 19	9·5320	14 23	9·9695	2 56
9 0	74 56	9·4148	11 20	9·9914	69 39	9·5407	14 37	9·9853	3 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	β Argûs. No. 17. Right Ascension, 9h 12m.		α Hydræ (Alphard). No. 18. Right Ascension, 9h 21m.		α1 Crucis (Foot of the Cross). No. 19. Right Ascension, 12h 19m.		α Virginis (Spica). No. 20. Right Ascension, 13h 18m.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	75 11	9·4228	11 32	10·0063	70 0	9·5487	14 53	10·0001	3 4
8 52	75 27	9·4312	11 45	10·0211	70 21	9·5554	15 8	10·0147	3 8
8 48	75 43	9·4379	11 58	10·0360	70 42	9·5642	15 26	10·0296	3 12
8 44	75 59	9·4451	12 12	10·0509	71 2	9·5727	15 43	10·0441	3 16
8 40	76 15	9·4524	12 26	10·0659	71 23	9·5798	16 2	10·0589	3 20
8 36	76 32	9·4588	12 41	10·0808	71 44	9·5873	16 21	10·0737	3 24
8 32	76 49	9·4652	12 57	10·0960	72 7	9·5949	16 40	10·0882	3 28
8 28	77 6	9·4715	13 14	10·1112	72 29	9·6016	17 2	10·1032	3 32
8 24	77 23	9·4778	13 33	10·1265	72 52	9·6074	17 25	10·1183	3 36
8 20	77 41	9·4837	13 53	10·1419	73 15	9·6135	17 49	10·1334	3 40
8 16	78 9	9·4894	14 13	10·1575	73 39	9·6197	18 13	10·1486	3 44
8 12	78 17	9·4949	14 36	10·1732	74 4	9·6258	18 41	10·1639	3 48
8 8	78 36	9·5001	14 59	10·1891	74 28	9·6315	19 11	10·1793	3 52
8 4	78 55	9·5052	15 24	10·2053	74 53	9·6370	19 42	10·1950	3 56
8 0	79 14	9·5103	15 50	10·2219	75 18	9·6424	20 14	10·2108	4 0
7 56	79 33	9·5151	16 18	10·2384	75 44	9·6476	20 49	10·2269	4 4
7 52	79 52	9·5196	16 49	10·2554	76 10	9·6525	21 25	10·2430	4 8
7 48	80 12	9·5239	17 20	10·2726	76 37	9·6570	22 6	10·2595	4 12
7 44	80 32	9·5280	17 56	10·2901	77 3	9·6614	22 49	10·2763	4 16
7 40	80 52	9·5320	18 33	10·3081	77 30	9·6658	23 35	10·2930	4 20
7 36	81 12	9·5360	19 12	10·3265	77 57	9·6702	24 21	10·3106	4 24
7 32	81 32	9·5397	19 58	10·3453	78 24	9·6745	25 15	10·3287	4 28
7 28	81 53	9·5432	20 45	10·3648	78 52	9·6783	26 12	10·3467	4 32
7 24	82 14	9·5466	21 33	10·3842	79 20	9·6818	27 13	10·3649	4 36
7 20	82 35	9·5499	22 27	10·4039	79 48	9·6853	28 21	10·3833	4 40
7 16	82 56	9·5529	23 27	10·4248	80 17	9·6886	29 32	10·4021	4 44
7 12	83 18	9·5556	24 34	10·4468	80 47	9·6918	30 48	10·4221	4 48
7 8	83 40	9·5582	25 42	10·4680	81 16	9·6948	32 9	10·4425	4 52
7 4	84 1	9·5608	27 7	10·4908	81 45	9·6975	33 48	10·4625	4 56
7 0	84 22	9·5633	28 37	10·5150	82 16	9·7001	35 33	10·4826	5 0
6 56	84 44	9·5655	30 14	10·5376	82 46	9·7026	37 20	10·5024	5 4
6 52	85 6	9·5675	32 7	10·5628	83 16	9·7051	39 20	10·5241	5 8
6 48	85 29	9·5695	34 13	10·5894	83 46	9·7071	41 30	10·5465	5 12
6 44	85 51	9·5713	36 36	10·6148	84 16	9·7091	43 51	10·5690	5 16
6 40	86 13	9·5729	39 12	10·6431	84 47	9·7109	46 38	10·5939	5 20
6 36	86 36	9·5743	42 9	10·6701	84 18	9·7123	49 35	10·6112	5 24
6 32	86 58	9·5755	45 47	10·6976	85 49	9·7136	52 50	10·6323	5 28
6 28	87 20	9·5766	49 19	10·7210	86 20	9·7149	56 25	10·6526	5 32
6 24	87 43	9·5776	53 36	10·7529	86 51	9·7162	60 30	10·6713	5 36
6 20	88 6	9·5786	58 26	10·7779	87 22	9·7171	64 34	10·6882	5 40
6 16	88 29	9·5792	63 49	10·8001	87 54	9·7184	69 10	10·7041	5 44
6 12	88 51	9·5797	69 40	10·8200	88 25	9·7186	74 3	10·7189	5 48
6 8	89 14	9·5801	76 10	10·8349	88 57	9·7190	79 13	10·7255	5 52
6 4	89 37	9·5803	82 58	10·8361	89 29	9·7192	84 33	10·7324	5 56
6 0	90 0	9·5803	90 0	10·8485	90 0	9·7192	90 0	10·7342	6 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	α^2 Centauri. No. 21. Right Ascension, $14^h\ 30^m$.		α^2 Libræ. No. 22. Right Ascension, $14^h\ 43^m$.		α Scorpii (Antares). No. 23. Right Ascension, $16^h\ 21^m$.		α Pavonis. No. 24. Right Ascension, $20^h\ 15^m$.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
11 56	60 16	7·9368	15 29	8·2258	26 8	8·1950	57 10	7·9747	0 4
11 52	60 17	8·2381	15 29	8·4270	26 9	8·4962	57 11	8·2758	0 8
11 48	60 18	8·4149	15 30	8·7033	26 10	8·6725	57 12	8·4520	0 12
11 44	60 19	8·5387	15 31	8·8284	26 11	8·7975	57 14	8·5769	0 16
11 40	60 21	8·6357	15 32	8·9258	26 13	8·8946	57 16	8·6740	0 20
11 36	60 25	8·7148	15 34	9·0054	26 15	9·0143	57 18	8·7532	0 24
11 32	60 30	8·7816	15 36	9·0729	26 18	9·0416	57 21	8·8202	0 28
11 28	60 34	8·8396	15 38	9·1315	26 21	9·1001	57 25	8·8783	0 32
11 24	60 38	8·8906	15 40	9·1832	26 25	9·1518	57 29	8·9295	0 36
11 20	60 42	8·9363	15 43	9·2297	26 29	9·1980	57 35	8·9754	0 40
11 16	60 47	8·9777	15 46	9·2720	26 33	9·2404	57 40	9·0169	0 44
11 12	60 52	9·0152	15 49	9·3107	26 38	9·2788	57 46	9·0545	0 48
11 8	60 57	9·0498	15 52	9·3465	26 44	9·3142	57 52	9·0893	0 52
11 4	61 3	9·0818	15 56	9·3798	26 50	9·3473	57 58	9·1215	0 56
11 0	61 9	9·1116	16 0	9·4109	26 56	9·3783	58 6	9·1515	1 0
10 56	61 16	9·1394	16 4	9·4402	27 3	9·4072	58 14	9·1793	1 4
10 52	61 23	9·1656	16 9	9·4669	27 10	9·4347	58 22	9·2056	1 8
10 48	61 31	9·1902	16 14	9·4941	27 17	9·4606	58 30	9·2304	1 12
10 44	61 39	9·2135	16 19	9·5191	27 25	9·4851	58 39	9·2538	1 16
10 40	61 47	9·2355	16 25	9·5430	27 34	9·5087	58 48	9·2758	1 20
10 36	61 55	9·2564	16 31	9·5658	27 43	9·5313	58 58	9·2969	1 24
10 32	62 4	9·2763	16 38	9·5877	27 53	9·5529	59 8	9·3175	1 28
10 28	62 14	9·2953	16 45	9·6090	28 3	9·5738	59 19	9·3360	1 32
10 24	62 25	9·3134	16 52	9·6285	28 14	9·5938	59 30	9·3542	1 36
10 20	62 37	9·3308	17 0	9·6493	28 25	9·6129	59 42	9·3717	1 40
10 16	60 49	9·3474	17 8	9·6685	28 37	9·6317	59 54	9·3886	1 44
10 12	63 1	9·3634	17 16	9·6871	28 50	9·6500	60 7	9·4047	1 48
10 8	63 13	9·3743	17 25	9·7053	29 3	9·6672	60 20	9·4102	1 52
10 4	63 27	9·3937	17 34	9·7231	29 17	9·6845	60 34	9·4352	1 56
10 0	63 41	9·4058	17 44	9·7402	29 32	9·7011	60 48	9·4496	2 0
9 56	63 55	9·4215	17 55	9·7571	29 47	9·7172	61 3	9·4634	2 4
9 52	64 10	9·4348	18 6	9·7737	30 2	9·7331	61 18	9·4769	2 8
9 48	64 25	9·4476	18 17	9·7900	30 18	9·7488	61 34	9·4899	2 12
9 44	64 41	9·4601	18 29	9·8061	30 35	9·7639	61 50	9·5026	2 16
9 40	64 57	9·4720	18 41	9·8217	30 53	9·7788	62 7	9·5147	2 20
9 36	65 13	9·4837	18 54	9·8373	31 13	9·7934	62 25	9·5266	2 24
9 32	65 30	9·4949	19 8	9·8525	31 33	9·8076	62 43	9·5381	2 28
9 28	65 48	9·5058	19 22	9·8675	31 54	9·8217	63 3	9·5492	2 32
9 24	66 6	9·5164	19 37	9·8825	32 15	9·8358	63 22	9·5599	2 36
9 20	66 24	9·5266	19 53	9·8972	32 37	9·8494	63 41	9·5703	2 40
9 16	66 42	9·5366	20 10	9·9118	33 0	9·8630	64 2	9·5805	2 44
9 12	67 1	9·5461	20 27	9·9262	33 24	9·8760	64 22	9·5903	2 48
9 8	67 20	9·5555	20 46	9·9407	33 50	9·8890	64 43	9·5999	2 52
9 4	67 40	9·5644	21 5	9·9648	34 16	9·9021	65 5	9·6091	2 56
9 0	68 0	9·5732	21 24	9·9690	34 45	9·9149	65 28	9·6181	3 0

TABLE VII.—DECLINATION SOUTH.

Hour Angle.	α^3 Centauri. No. 21. Right Ascension, $14^h\ 30^m$.		α^3 Libræ. No. 22. Right Ascension, $14^h\ 45^m$.		α Scorpii (Antares). No. 23. Right Ascension, $16^h\ 21^m$.		α Pavonis. No. 24. Right Ascension, $20^h\ 15^m$.		Hour Angle.
	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	Arc I.	Log. I.	
H. M.	° ′		° ′		° ′		° ′		H. M.
8 56	68 21	9·5815	21 45	9·9832	35 14	9·9272	65 52	9·6269	3 4
8 52	68 43	9·5896	22 8	9·9972	35 44	9·9396	66 15	9·6354	3 8
8 48	69 6	9·5976	22 30	10·0113	36 14	9·9521	66 40	9·6437	3 12
8 44	69 28	9·6068	22 54	10·0252	36 46	9·9644	67 5	9·6516	3 16
8 40	69 51	9·6132	23 19	10·0393	37 20	9·9766	67 30	9·6593	3 20
8 36	70 14	9·6208	23 46	10·0532	37 56	9·9885	67 55	9·6671	3 24
8 32	70 37	9·6283	24 14	10·0670	38 32	10·0004	68 21	9·6745	3 28
8 28	71 1	9·6351	24 44	10·0811	39 9	10·0124	68 47	9·6816	3 32
8 24	71 26	9·6414	25 15	10·0952	39 50	10·0239	69 15	9·6885	3 36
8 20	71 51	9·6477	25 36	10·1093	40 29	10·0355	69 42	9·6951	3 40
8 16	72 16	9·6541	26 21	10·1234	41 13	10·0470	70 10	9·7017	3 44
8 12	72 42	9·6603	26 57	10·1375	42 0	10·0585	70 39	9·7081	3 48
8 8	73 8	9·6661	27 35	10·1516	42 47	10·0701	71 7	9·7142	3 52
8 4	73 36	9·6718	28 15	10·1659	43 36	10·0807	71 36	9·7200	3 56
8 0	74 4	9·6773	28 58	10·1805	44 26	10·0922	72 7	9·7258	4 0
7 56	74 32	9·6822	29 42	10·1949	45 22	10·1032	72 38	9·7311	4 4
7 52	75 0	9·6876	30 31	10·2095	46 16	10·1146	73 9	9·7363	4 8
7 48	75 29	9·6925	31 22	10·2242	47 12	10·1248	73 41	9·7416	4 12
7 44	75 59	9·6972	32 17	10·2389	48 14	10·1354	74 13	9·7467	4 16
7 40	76 30	9·7017	33 14	10·2537	49 16	10·1460	74 45	9·7514	4 20
7 36	77 0	9·7061	34 15	10·2685	50 19	10·1573	75 18	9·7559	4 24
7 32	77 30	9·7105	35 20	10·2834	51 28	10·1674	75 51	9·7605	4 28
7 28	78 0	9·7145	36 30	10·2987	52 38	10·1772	76 25	9·7648	4 32
7 24	78 30	9·7181	37 41	10·3142	53 52	10·1867	76 58	9·7686	4 36
7 20	79 0	9·7217	39 0	10·3300	55 8	10·1858	77 33	9·7722	4 40
7 16	79 30	9·7251	40 23	10·3451	56 26	10·2059	78 8	9·7758	4 44
7 12	80 1	9·7285	41 51	10·3602	57 48	10·2150	78 43	9·7794	4 48
7 8	80 33	9·7316	43 12	10·3762	59 13	10·2236	79 19	9·7827	4 52
7 4	81 5	9·7345	45 1	10·3915	60 41	10·2324	79 55	9·7857	4 56
7 0	81 37	9·7372	46 55	10·4062	62 11	10·2408	80 31	9·7886	5 0
6 56	81 10	9·7397	48 56	10·4212	63 45	10·2505	81 7	9·7912	5 4
6 52	81 43	9·7422	51 0	10·4361	65 23	10·2581	81 44	9·7937	5 8
6 48	82 16	9·7444	53 4	10·4509	67 3	10·2640	82 21	9·7961	5 12
6 44	82 49	9·7464	55 28	10·4672	68 43	10·2710	82 58	9·7982	5 16
6 40	84 22	9·7483	57 56	10·4790	70 29	10·2773	83 36	9·8002	5 20
6 36	84 56	9·7499	60 30	10·4919	72 19	10·2831	84 14	9·8021	5 24
6 32	85 29	9·7513	63 16	10·5042	74 10	10·2884	84 52	9·8037	5 28
6 28	86 2	9·7527	66 12	10·5158	76 2	10·2933	85 30	9·8051	5 32
6 24	86 35	9·7539	69 18	10·5270	77 58	10·2972	86 8	9·8063	5 36
6 20	87 9	9·7548	72 31	10·5353	79 55	10·3008	86 46	9·8073	5 40
6 16	87 43	9·7559	75 51	10·5428	81 55	10·3039	87 25	9·8082	5 44
6 12	88 17	9·7563	79 16	10·5491	83 55	10·3063	88 3	9·8088	5 48
6 8	88 51	9·7566	82 49	10·5537	85 55	10·3079	88 42	9·8095	5 52
6 4	89 25	9·7568	86 23	10·5561	87 58	10·3090	89 21	9·8097	5 56
6 0	90 0	9·7568	90 0	10·5575	90 0	10·3093	90 0	9·8097	6 0

TABLE VIII.—LOGARITHMS OF ARC II.,
To be added to Log. I., which will give Logarithm of True Azimuth.

Degrees.	0 M.	10 M.	20 M.	30 M.	40 M.	50 M.	50 M.	40 M.	30 M.	20 M.	10 M.	0 M.	Degrees.
0	Infinite.	2·5363	2·2352	2·0592	1·9342	1·8373	0·1443	0·1455	0·1468	0·1480	0·1493	0·1505	45
1	1·7581	1·6912	1·6332	1·5821	1·5363	1·4950	0·1371	0·1382	0·1394	0·1406	0·1418	0·1431	46
2	1·4572	1·4224	1·3903	1·3603	1·3323	1·3060	0·1301	0·1312	0·1324	0·1335	0·1347	0·1359	47
3	1·2812	1·2577	1·2355	1·2143	1·1941	1·1749	0·1233	0·1244	0·1255	0·1267	0·1278	0·1289	48
4	1·1564	1·1387	1·1217	1·1054	1·0896	1·0744	0·1168	0·1179	0·1190	0·1200	0·1211	0·1222	49
5	1·0597	1·0455	1·0318	1·0184	1·0055	0·9930	0·1105	0·1116	0·1126	0·1136	0·1147	0·1157	50
6	0·9808	0·9689	0·9574	0·9461	0·9352	0·9245	0·1045	0·1055	0·1065	0·1075	0·1085	0·1095	51
7	0·9141	0·9039	0·8940	0·8843	0·8748	0·8655	0·0986	0·0996	0·1005	0·1015	0·1025	0·1035	52
8	0·8564	0·8475	0·8388	0·8303	0·8219	0·8137	0·0930	0·0939	0·0948	0·0958	0·0967	0·0976	53
9	0·8057	0·7978	0·7900	0·7824	0·7749	0·7676	0·0875	0·0884	0·0893	0·0902	0·0911	0·0920	54
10	0·7603	0·7532	0·7462	0·7394	0·7326	0·7260	0·0823	0·0831	0·0840	0·0849	0·0858	0·0866	55
11	0·7194	0·7130	0·7066	0·7003	0·6942	0·6881	0·0772	0·0781	0·0789	0·0797	0·0806	0·0814	56
12	0·6821	0·6762	0·6704	0·6647	0·6590	0·6534	0·0724	0·0732	0·0740	0·0748	0·0756	0·0764	57
13	0·6479	0·6425	0·6371	0·6318	0·6266	0·6214	0·0677	0·0685	0·0692	0·0700	0·0708	0·0716	58
14	0·6163	0·6113	0·6063	0·6014	0·5965	0·5917	0·0632	0·0639	0·0647	0·0654	0·0662	0·0669	59
15	0·5870	0·5823	0·5777	0·5731	0·5686	0·5641	0·0589	0·0596	0·0603	0·0610	0·0617	0·0625	60
16	0·5597	0·5553	0·5509	0·5467	0·5424	0·5382	0·0547	0·0554	0·0561	0·0568	0·0575	0·0582	61
17	0·5341	0·5300	0·5259	0·5219	0·5179	0·5139	0·0508	0·0514	0·0521	0·0527	0·0534	0·0541	62
18	0·5100	0·5061	0·5023	0·4985	0·4948	0·4910	0·0470	0·0476	0·0482	0·0488	0·0495	0·0501	63
19	0·4874	0·4837	0·4801	0·4765	0·4730	0·4694	0·0433	0·0439	0·0445	0·0451	0·0457	0·0463	64
20	0·4659	0·4625	0·4591	0·4557	0·4523	0·4490	0·0398	0·0404	0·0410	0·0416	0·0421	0·0427	65
21	0·4457	0·4424	0·4391	0·4359	0·4327	0·4296	0·0365	0·0371	0·0376	0·0382	0·0387	0·0393	66
22	0·4264	0·4233	0·4202	0·4172	0·4141	0·4111	0·0333	0·0339	0·0344	0·0349	0·0354	0·0360	67
23	0·4081	0·4052	0·4022	0·3993	0·3964	0·3935	0·0303	0·0308	0·0313	0·0318	0·0323	0·0328	68
24	0·3907	0·3879	0·3851	0·3823	0·3795	0·3768	0·0275	0·0279	0·0284	0·0289	0·0294	0·0298	69
25	0·3741	0·3714	0·3687	0·3660	0·3634	0·3608	0·0248	0·0252	0·0257	0·0261	0·0266	0·0270	70
26	0·3582	0·3556	0·3530	0·3505	0·3479	0·3454	0·0222	0·0226	0·0230	0·0235	0·0239	0·0243	71
27	0·3430	0·3405	0·3380	0·3356	0·3332	0·3308	0·0198	0·0202	0·0206	0·0210	0·0214	0·0218	72
28	0·3284	0·3260	0·3237	0·3213	0·3190	0·3167	0·0175	0·0179	0·0183	0·0186	0·0190	0·0194	73
29	0·3144	0·3122	0·3099	0·3077	0·3054	0·3032	0·0154	0·0157	0·0161	0·0164	0·0168	0·0172	74
30	0·3010	0·2988	0·2967	0·2945	0·2924	0·2903	0·0134	0·0137	0·0141	0·0144	0·0147	0·0151	75
31	0·2882	0·2861	0·2840	0·2819	0·2799	0·2778	0·0116	0·0119	0·0122	0·0125	0·0128	0·0131	76
32	0·2758	0·2738	0·2718	0·2698	0·2678	0·2658	0·0099	0·0101	0·0104	0·0107	0·0110	0·0113	77
33	0·2639	0·2620	0·2600	0·2581	0·2562	0·2543	0·0083	0·0086	0·0088	0·0091	0·0093	0·0096	78
34	0·2524	0·2506	0·2487	0·2469	0·2450	0·2432	0·0069	0·0071	0·0073	0·0076	0·0078	0·0081	79
35	0·2414	0·2396	0·2378	0·2360	0·2343	0·2325	0·0056	0·0058	0·0060	0·0062	0·0064	0·0066	80
36	0·2308	0·2290	0·2273	0·2256	0·2239	0·2222	0·0044	0·0046	0·0048	0·0050	0·0052	0·0054	81
37	0·2205	0·2189	0·2172	0·2156	0·2139	0·2123	0·0034	0·0036	0·0037	0·0039	0·0041	0·0042	82
38	0·2107	0·2090	0·2074	0·2058	0·2043	0·2027	0·0025	0·0027	0·0028	0·0029	0·0031	0·0032	83
39	0·2011	0·1996	0·1980	0·1965	0·1950	0·1934	0·0018	0·0019	0·0020	0·0021	0·0023	0·0024	84
40	0·1919	0·1904	0·1889	0·1875	0·1860	0·1845	0·0011	0·0012	0·0013	0·0014	0·0015	0·0017	85
41	0·1831	0·1816	0·1802	0·1787	0·1773	0·1759	0·0007	0·0007	0·0008	0·0009	0·0010	0·0011	86
42	0·1745	0·1731	0·1717	0·1703	0·1689	0·1676	0·0003	0·0004	0·0004	0·0005	0·0005	0·0006	87
43	0·1662	0·1649	0·1635	0·1622	0·1609	0·1595	0·0001	0·0001	0·0001	0·0002	0·0002	0·0003	88
44	0·1582	0·1569	0·1556	0·1543	0·1531	0·1518	0·0000	0·0000	0·0000	0·0000	0·0000	0·0001	89

TABLE IX.—LOGARITHMS OF TRUE AZIMUTHS

To be named South in North Latitude, or North in South Latitude, if the Latitude and Declination be one North and the other South, or when both are either North or South, and Arc I. is less than the Latitude; but if the Latitude and Declination be both North or both South, and Arc I. be greater than the Latitude, or the Time from Meridian Passage be more than Six Hours, the Azimuth will be North in North Latitude or South in South Latitude.

Degrees.	0 M.	10 M.	20 M.	30 M.	40 M.	50 M.	50 M.	40 M.	30 M.	20 M.	10 M.	0 M.	Degrees.
0	0·0000	7·4637	7·7648	7·9409	8·0658	8·1627	10·0126	10·0101	10·0076	10·0051	10·0025	10·0000	45
1	8·2419	8·3089	8·3669	8·4181	8·4638	8·5053	10·0278	10·0253	10·0227	10·0202	10·0177	10·0152	46
2	8·5431	8·5779	8·6101	8·6401	8·6682	8·6945	10·0430	10·0405	10·0379	10·0354	10·0329	10·0303	47
3	8·7194	8·7429	8·7652	8·7865	8·8067	8·8261	10·0583	10·0557	10·0532	10·0506	10·0481	10·0456	48
4	8·8446	8·8624	8·8795	8·8960	8·9118	8·9272	10·0736	10·0711	10·0685	10·0659	10·0634	10·0608	49
5	8·9420	8·9563	8·9701	8·9836	8·9966	9·0093	10·0890	10·0865	10·0839	10·0813	10·0788	10·0762	50
6	9·0216	9·0336	9·0453	9·0567	9·0678	9·0786	10·1046	10·1020	10·0994	10·0968	10·0942	10·0916	51
7	9·0891	9·0995	9·1096	9·1194	9·1291	9·1385	10·1203	10·1176	10·1150	10·1124	10·1098	10·1072	52
8	9·1478	9·1569	9·1658	9·1745	9·1831	9·1915	10·1361	10·1334	10·1308	10·1282	10·1255	10·1229	53
9	9·1997	9·2078	9·2158	9·2236	9·2313	9·2389	10·1521	10·1494	10·1467	10·1441	10·1414	10·1387	54
10	9·2463	9·2536	9·2609	9·2680	9·2750	9·2819	10·1683	10·1656	10·1629	10·1602	10·1575	10·1548	55
11	9·2887	9·2953	9·3020	9·3085	9·3149	9·3212	10·1847	10·1820	10·1792	10·1765	10·1737	10·1710	56
12	9·3275	9·3336	9·3397	9·3458	9·3517	9·3576	10·2014	10·1986	10·1958	10·1930	10·1903	10·1875	57
13	9·3634	9·3691	9·3748	9·3804	9·3859	9·3914	10·2184	10·2155	10·2127	10·2098	10·2070	10·2042	58
14	9·3968	9·4021	9·4074	9·4127	9·4178	9·4230	10·2356	10·2327	10·2299	10·2270	10·2241	10·2212	59
15	9·4281	9·4331	9·4381	9·4430	9·4479	9·4527	10·2533	10·2503	10·2474	10·2444	10·2415	10·2386	60
16	9·4575	9·4622	9·4669	9·4716	9·4762	9·4808	10·2713	10·2683	10·2652	10·2622	10·2592	10·2562	61
17	9·4853	9·4898	9·4943	9·4987	9·5031	9·5075	10·2897	10·2866	10·2835	10·2804	10·2774	10·2743	62
18	9·5118	9·5161	9·5203	9·5245	9·5287	9·5329	10·3086	10·3054	10·3023	10·2991	10·2960	10·2928	63
19	9·5370	9·5411	9·5451	9·5491	9·5531	9·5571	10·3280	10·3248	10·3215	10·3183	10·3150	10·3118	64
20	9·5611	9·5650	9·5689	9·5727	9·5766	9·5804	10·3480	10·3447	10·3413	10·3380	10·3346	10·3313	65
21	9·5842	9·5879	9·5917	9·5954	9·5991	9·6028	10·3686	10·3652	10·3617	10·3583	10·3548	10·3514	66
22	9·6064	9·6100	9·6136	9·6172	9·6208	9·6243	10·3900	10·3864	10·3828	10·3792	10·3757	10·3721	67
23	9·6279	9·6314	9·6348	9·6383	9·6417	9·6452	10·4121	10·4083	10·4046	10·4009	10·3972	10·3936	68
24	9·6486	9·6520	9·6553	9·6587	9·6620	9·6654	10·4350	10·4311	10·4273	10·4234	10·4196	10·4158	69
25	9·6687	9·6720	9·6752	9·6785	9·6817	9·6850	10·4589	10·4549	10·4509	10·4469	10·4429	10·4389	70
26	9·6882	9·6914	9·6946	9·6977	9·7009	9·7040	10·4839	10·4797	10·4755	10·4713	10·4671	10·4630	71
27	9·7072	9·7103	9·7134	9·7165	9·7196	9·7226	10·5102	10·5057	10·5013	10·4969	10·4925	10·4882	72
28	9·7257	9·7287	9·7317	9·7348	9·7378	9·7408	10·5378	10·5331	10·5284	10·5238	10·5192	10·5147	73
29	9·7438	9·7467	9·7497	9·7526	9·7556	9·7585	10·5669	10·5619	10·5570	10·5521	10·5473	10·5425	74
30	9·7614	9·7644	9·7673	9·7701	9·7730	9·7759	10·5979	10·5926	10·5873	10·5822	10·5770	10·5719	75
31	9·7788	9·7816	9·7845	9·7873	9·7902	9·7930	10·6309	10·6252	10·6196	10·6141	10·6086	10·6032	76
32	9·7958	9·7986	9·8014	9·8042	9·8070	9·8097	10·6664	10·6603	10·6542	10·6483	10·6424	10·6366	77
33	9·8125	9·8153	9·8180	9·8208	9·8235	9·8263	10·7047	10·6980	10·6915	10·6851	10·6788	10·6725	78
34	9·8290	9·8317	9·8344	9·8371	9·8398	9·8425	10·7464	10·7391	10·7320	10·7250	10·7181	10·7113	79
35	9·8452	9·8479	9·8506	9·8533	9·8559	9·8586	10·7922	10·7842	10·7764	10·7687	10·7611	10·7537	80
36	9·8613	9·8639	9·8666	9·8692	9·8718	9·8745	10·8431	10·8342	10·8255	10·8169	10·8085	10·8003	81
37	9·8771	9·8797	9·8824	9·8850	9·8876	9·8902	10·9005	10·8904	10·8806	10·8709	10·8615	10·8522	82
38	9·8928	9·8954	9·8980	9·9006	9·9032	9·9058	10·9664	10·9547	10·9433	10·9322	10·9214	10·9109	83
39	9·9084	9·9110	9·9135	9·9161	9·9187	9·9212	11·0437	11·0299	11·0164	11·0034	10·9907	10·9784	84
40	9·9238	9·9264	9·9289	9·9315	9·9341	9·9366	11·1376	11·1205	11·1040	11·0882	11·0728	11·0580	85
41	9·9392	9·9417	9·9443	9·9468	9·9494	9·9519	11·2571	11·2348	11·2135	11·1933	11·1739	11·1554	86
42	9·9544	9·9570	9·9595	9·9621	9·9646	9·9671	11·4221	11·3899	11·3599	11·3318	11·3055	11·2806	87
43	9·9697	9·9722	9·9747	9·9772	9·9798	9·9823	11·6911	11·6331	11·5819	11·5362	11·4947	11·4569	88
44	9·9848	9·9874	9·9899	9·9924	9·9949	9·9975	12·5363	12·2352	12·0591	11·9342	11·8373	11·7581	89

TABLE X.

C. North {	N. by E. N. by W.	N.N.E. N.N.W.	N.E. by N. N.W. by N.	N.E. N.W.	N.E. by E. N.W. by W.	E.N.E. W.N.W.	E. by N. W. by N.	East. West.
B. East {	E. by N. E. by S.	E.N.E. E.S.E.	N.E. by E. S.E. by E.	N.E. S.E.	N.E. by N. S.E. by S.	N.N.E. S.S.E.	N. by E. S. by E.	North. South.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
0 15	0 15	0 14	0 12	0 11	0 8	0 6	0 3	0 0
0 30	0 29	0 28	0 25	0 21	0 17	0 11	0 6	0 0
0 45	0 44	0 42	0 37	0 32	0 25	0 17	0 9	0 0
1 0	0 59	0 55	0 50	0 42	0 33	0 23	0 12	0 0
1 15	1 14	1 9	1 2	0 53	0 42	0 29	0 15	0 0
1 30	1 28	1 23	1 15	1 4	0 50	0 34	0 18	0 0
1 45	1 43	1 37	1 27	1 14	0 58	0 40	0 21	0 0
2 0	1 58	1 51	1 40	1 25	1 7	0 46	0 23	0 0
2 15	2 12	2 5	1 52	1 36	1 15	0 52	0 26	0 0
2 30	2 27	2 19	2 5	1 46	1 23	0 57	0 29	0 0
2 45	2 42	2 32	2 17	1 57	1 32	1 3	0 32	0 0
3 0	2 57	2 46	2 30	2 7	1 40	1 9	0 35	0 0
3 15	3 11	3 0	2 42	2 13	1 48	1 15	0 38	0 0
3 30	3 26	3 14	2 55	2 29	1 57	1 20	0 41	0 0
3 45	3 41	3 28	3 7	2 39	2 5	1 26	0 44	0 0
4 0	3 55	3 42	3 20	2 50	2 18	1 32	0 47	0 0
4 15	4 10	3 56	3 32	3 0	2 22	1 38	0 50	0 0
4 30	4 25	4 10	3 45	3 11	2 30	1 43	0 53	0 0
4 45	4 40	4 23	3 57	3 22	2 38	1 49	0 56	0 0
5 0	4 54	4 37	4 9	3 32	2 47	1 55	0 59	0 0
5 15	5 9	4 51	4 22	3 43	2 55	2 1	1 2	0 0
5 30	5 24	5 5	4 34	3 53	3 3	2 6	1 4	0 0
5 45	5 38	5 19	4 47	4 4	3 12	2 12	1 7	0 0
6 0	5 53	5 33	4 59	4 15	3 20	2 18	1 10	0 0
6 15	6 8	5 46	5 12	4 25	3 28	2 24	1 13	0 0
6 30	6 23	6 0	5 24	4 36	3 37	2 29	1 16	0 0
6 45	6 37	6 14	5 37	4 46	3 45	2 35	1 19	0 0
7 0	6 52	6 28	5 49	4 57	3 53	2 41	1 22	0 0
7 15	7 7	6 42	6 2	5 8	4 2	2 47	1 25	0 0
7 30	7 21	6 56	6 14	5 18	4 10	2 52	1 28	0 0
7 45	7 36	7 10	6 27	5 29	4 18	2 58	1 31	0 0
8 0	7 51	7 24	6 39	5 39	4 27	3 4	1 34	0 0
8 15	8 6	7 37	6 52	5 50	4 35	3 10	1 37	0 0
8 30	8 20	7 51	7 4	6 1	4 43	3 15	1 40	0 0
8 45	8 35	8 5	7 16	6 11	4 52	3 21	1 42	0 0
9 0	8 50	8 19	7 29	6 22	5 0	3 27	1 45	0 0
9 15	9 4	8 33	7 41	6 32	5 8	3 32	1 48	0 0
9 30	9 19	8 47	7 54	6 43	5 17	3 38	1 51	0 0
9 45	9 34	9 0	8 6	6 54	5 25	3 44	1 54	0 0
10 0	9 48	9 14	8 19	7 4	5 33	3 50	1 57	0 0
B. West {	W. by S. W. by N.	W.S.W. W.N.W.	S.W. by W. N.W. by W.	S.W. N.W.	S.W. by S. N.W. by N.	S.S.W. N.N.W.	S. by W. N. by W.	South. North.
C. South {	*S. by W. S. by E.*	S.S.W. S.S.E.	S.W. by S. S.E. by S.	S.W. S.E.	S.W. by W. S.E. by E.	W.S.W. E.S.E.	W. by S. E. by S.	West. East.

TABLE X.

C. North {	N. by E. N. by W.	N.N.E. N.N.W.	N.E. by N. N.W. by N.	N.E. N.W.	N.E. by E. N.W. by W.	E.N.E. W.N.W.	E. by N. W. by N.	East. West.
B. East {	E. by N. E. by S.	E.N.E. E.S.E.	N.E. by E. S.E. by E.	N.E. S.E.	N.E. by N. S.E. by S.	N.N.E. S.S.E.	N. by E. S. by E.	North. South.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
10 15	10 3	9 28	9 31	7 15	5 42	3 55	2 0	0 0
10 30	10 18	9 42	8 44	7 25	5 50	4 1	2 3	0 0
10 45	10 33	9 56	8 56	7 36	5 58	4 7	2 6	0 0
11 0	10 47	10 10	9 9	7 47	6 7	4 13	2 9	0 0
11 15	11 2	10 24	9 21	7 57	6 15	4 18	2 12	0 0
11 30	11 17	10 37	9 34	8 8	6 23	4 24	2 15	0 0
11 45	11 32	10 51	9 46	8 19	6 32	4 30	2 18	0 0
12 0	11 46	11 5	9 59	8 29	6 40	4 36	2 20	0 0
12 15	12 1	11 19	10 11	8 40	6 48	4 41	2 23	0 0
12 30	12 16	11 33	10 24	8 50	6 57	4 47	2 26	0 0
12 45	12 30	11 47	10 36	9 1	7 5	4 53	2 29	0 0
13 0	12 45	12 1	10 49	9 12	7 13	4 58	2 32	0 0
13 15	13 0	12 14	11 1	9 22	7 22	5 4	2 35	0 0
13 30	13 14	12 28	11 13	9 33	7 30	5 10	2 38	0 0
13 45	13 29	12 42	11 26	9 43	7 38	5 16	2 41	0 0
14 0	13 44	12 56	11 38	9 54	7 47	5 21	2 44	0 0
14 15	13 59	13 10	11 51	10 5	7 55	5 27	2 47	0 0
14 30	14 13	13 24	12 3	10 15	8 3	5 33	2 50	0 0
14 45	14 28	13 37	12 16	10 26	8 12	5 39	2 53	0 0
15 0	14 43	13 51	12 28	10 36	8 20	5 44	2 56	0 0
15 15	14 58	14 5	12 41	10 47	8 28	5 50	2 59	0 0
15 30	15 12	14 19	12 53	10 58	8 37	5 56	3 1	0 0
15 45	15 27	14 33	13 6	11 8	8 45	6 2	3 4	0 0
16 0	15 42	14 47	13 18	11 19	8 53	6 7	3 7	0 0
16 15	15 56	15 1	13 31	11 29	9 2	6 13	3 10	0 0
16 30	16 11	15 15	13 43	11 40	9 10	6 19	3 13	0 0
16 45	16 26	15 29	13 55	11 51	9 18	6 25	3 16	0 0
17 0	16 40	15 42	14 8	12 1	9 27	6 30	3 19	0 0
17 15	16 55	15 56	14 20	12 12	9 35	6 36	3 22	0 0
17 30	17 10	16 10	14 33	12 22	9 43	6 42	3 25	0 0
17 45	17 25	16 24	14 45	12 33	9 52	6 48	3 28	0 0
18 0	17 39	16 38	14 58	12 44	10 0	6 53	3 31	0 0
18 15	17 54	16 52	15 10	12 54	10 8	6 59	3 34	0 0
18 30	18 9	17 6	15 23	13 5	10 17	7 5	3 37	0 0
18 45	18 23	17 20	15 36	13 16	10 25	7 10	3 40	0 0
19 0	18 38	17 33	15 48	13 26	10 33	7 16	3 42	0 0
19 15	18 53	17 47	16 0	13 37	10 41	7 22	3 45	0 0
19 30	19 7	18 1	16 13	13 47	10 50	7 28	3 48	0 0
19 45	19 22	18 15	16 25	13 58	10 58	7 34	3 51	0 0
20 0	19 37	18 29	16 38	14 8	11 7	7 39	3 54	0 0
B. West {	W. by S. W. by N.	W.S.W. W.N.W.	S.W. by W. N.W. by W.	S.W. N.W.	S.W. by S. N.W. by N.	S.S.W. N.N.W.	S. by W. N. by W.	South. North.
C. South {	S. by W. S. by E.	S.S.W. S.S.E.	S.W. by S. S.E. by S.	S.W. S.E.	S.W. by W. S.E. by E.	W.S.W. E.S.E.	W. by S. E. by S.	West. East.

Appendix A.

Construction of Tables.

Table I. is the sun's mean declination for every day taken from the mean of four years to the nearest thirty minutes with which Table III. is to be entered.

Table II. shows the bearing of Polaris for different latitudes and hours, sidereal time. This will serve to point out to those who take the bearing of the North Star for the determination of deviation the amount of dependence that can be placed on such observations, the error, however, may be corrected as in Example 13.

Tables III. and VII. are constructed on the formulæ of right-angled spherical trigonometry. Let P represent the elevated pole of the earth, or p the pole below the horizon; Z the zenith, and S the heavenly body, whose azimuth is observed, and the angle P Z S, the true azimuth.

Let fall a perpendicular S R on P Z, produced if necessary. This perpendicular is Arc I. In Fig. IV. substitute p for P.

$$\frac{\text{Cos S P R}}{\text{Cot P S}} = \tan \text{P R}$$

Fig. I.

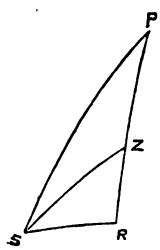


Fig. II.

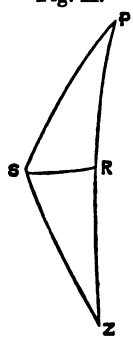


Fig. III.

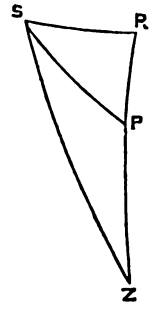


Fig. IV.

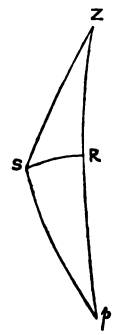
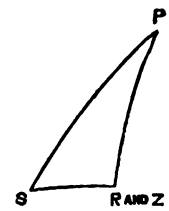


Fig. V.



The triangles S P R, S Z R, being right-angled at R, and having the base S R common, therefore,

$$\sin (\text{P R}) = \tan (\text{S R}) \,.\, \cot (\text{S P R})$$
$$\text{and } \sin (\text{Z R}) = \tan (\text{S R}) \,.\, \cot (\text{S Z R})$$
$$\therefore \frac{\sin (\text{P R})}{\sin (\text{Z R})} = \frac{\cot (\text{S P R})}{\cot (\text{S Z R})} = \frac{\tan (\text{S Z R})}{\tan (\text{S P R})}$$

this relation is expressed by saying that the tangents of the vertical angles S Z R, S P R are in inverse ratio of the sines of their respective perpendiculars R Z, R P.

And from the above relation we have at once

$$\tan (\text{S Z R}) = \text{cosec } (\text{Z R}) \,.\, \sin \text{P R} \,.\, \tan \text{S P R}.$$

Tables giving the azimuths for all latitudes, declinations, *and apparent* times would be too voluminous; therefore we

have given in Tables III. and VII. arc I., which is the complement of arc P R and log. I, which is the log. of (sin P R . tan S P R),

$$\text{and since, } Z\,R = \text{Lat.} \pm \text{arc I.} = \text{colat} \mp P\,R,$$
$$\text{therefore, log tan } S\,Z\,R = \text{log cosec } Z\,R \mp \text{log I.},$$

and the process of determining S Z R, the azimuth, is obvious.

Table VIII. contains the log. cosec of arcs to every 10′ for taking out the log cosec of Z R.

Table IX. contains the log. tan of arcs for every 10′, for obtaining the azimuth required; and since this occupies the page opposite to Table VIII. only one opening is necessary to take out the second log. and the required azimuth.

Table IV. shows the stars contained in Table VII., which are best situated for observation at different latitudes and for each hour of sidereal time.

Table V. gives the sun's mean R. A. diminished by four minutes to render the correction for long. and app. time additive in all cases.

Table VI. gives four minutes plus the acceleration or minus the retardation, as the case may be, for Greenwich date from the noon of the given day, twelve hours being added to all cases of a.m. to reduce the time shown by the watch to solar time.

Appendix B.

Vibration Experiments.

In the foot note to section 70, vibration experiments are referred to in connexion with compensation for heeling. The Astronomer Royal (Professor Airy) first applied this principle for the purpose of determining the magnetic condition of an iron ship. They are founded on the well-known law of dynamics,—that the forces required to produce vibrations of the same body, are in the ratios of the squares of the number of vibrations in a given time. The Liverpool Compass Committee have a compass adapted for determining both horizontal and vertical magnetic forces. The needle is mounted on an axis or staff, the pivots of which are very delicate, and run in jewel holes, with jewel end pieces, and the compass box is so mounted as to secure for the axis of the needle a position either perfectly vertical or horizontal, whichever may be required. Previously to this compass being used on ship-board it was made to vibrate on shore, in a place free from local attraction, in the first place horizontally, when the vibrations were found to be 20 in the minute of time, which was recorded. The axis of the needle was then placed horizontally, and in the direction north and south, by this compass. When thus placed the needle, when at rest, stood vertically, and it was made to vibrate towards the east and west point by compass. These vertical vibrations were found to be 33 per minute,

and, therefore, by adopting the above rule, we find that at Liverpool the vertical force of the earth's magnetism is to its horizontal force as 11 is to 4.

By trying the same experiments on ship-board we are enabled to determine the sum or difference of the earth's and ship's magnetism, either horizontal, with the ship's head in any given direction, or vertical; and the earth's magnetic force being already determined, in the manner above described, we can readily determine the ship's magnetic force in the terms of the earth's force.

Horizontal Vibration Experiments.

On board the "Simla," with the ship's head east by compass, (5)* the horizontal vibrations were 20 in 59 seconds, which shows that the ship's horizontal force, with the ship's head in this direction, was equal to ·034 of the earth's horizontal magnetism, and in the same direction. On the other hand, when the ship's head was west by compass, the needle had but little more than one-quarter of the directive force it had when on shore; there were only six vibrations in 35 seconds, showing the ship's magnetic force to have been in the opposite direction to that of the earth's, and that the ship's magnetic force was ·736* of that of the earth.

If it were not for the inductive magnetism of athwart-ship iron parallel to the deck, one-half the sum of the magnetic force on board an iron ship, with her head both east and west, would be equal to the earth's horizontal force, because the ship's sub-permanent magnetism, represented by C, would, with the ship's head in one direction, increase the directive force of the needle exactly to the same extent that it would decrease it when the ship's head was in the contrary direction, consequently the mean would be equal to the directive force on shore. Not so, however, with athwart-ship horizontal iron; if continuous from side to side it produces a +D, and reduces the directive force, either with the ship's head west or east, because the pole in the direction of the north pole of the earth must by induction be of a contrary name (foot note to 6), also the end towards the south attracts the same pole of the needle as is attracted by the north pole of the earth. But the contrary is the case if the horizontal iron be divided and

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* On board the "Simla," with her head east, the number of vibrations in 59 seconds were 20, the same number as were made on shore in 60 seconds, the number of vibrations, therefore, produced by the resultant of the earth's force, and the total magnetic force of the ship resolved in the same direction while her head was east, was $\frac{60}{59} = 1{\cdot}017$ to one on shore, and the resultant force therefore $1{\cdot}017^2 = 1{\cdot}034$. Adopting the same formula for determining the resultant magnetic force, with her head west, six vibrations in 35 seconds, being about 20 vibrations in 117 seconds, the ratio between the number of vibrations caused by the earth's magnetism is, to that produced by the resultant of earth's and ship's forces as 1 is to $\frac{60}{117} = {\cdot}5128$, and the resultant force as 1 is to $\cdot5128^2 = \cdot2639$. The total force of the ship's magnetism resolve in the direction of the needle, when it makes the ship's head appear east by compass was therefore $1{\cdot}034 - 1 = \cdot034$, the value of the earth's force being 1. But when the ship's head was west by compass the force of the ship's magnetism was $1 - \cdot2639 = \cdot7361$, and in the opposite direction to the earth's force.

the compass placed between the two ends. In this case a — D is produced, and the directive force of the needle is increased. Now correctors or chain boxes are of the nature of divided horizontal beams. They compensate + D, restore the directive force of the needle, and prevent that part of the change of deviation from heeling to the extent of the — D thus produced. In the experiments above given we find that the mean directive force is reduced from 40 to 26.* From this reduction of the mean directive force we can calculate the total value of + D to be a little more than 10°; but the D observed in swinging the "Simla" was only + 7° 50′. By these vibration experiments we then find this + 7° 50′ is the algebraic sum (52) of + 10° and — 2° 10′, the latter resulting from fore and aft horizontal iron. We have shown in Section 68 that although the — D produced by fore and aft iron reduces the + D observed whilst the ship is on an even beam, it does not reduce the amount of that change of deviation from heeling which arises from athwart-ship iron, because the position of fore and aft iron is not altered by heeling, but still continues horizontal.

Vertical Vibration Experiments.

In the foot note to section 70 it is stated that when by vibration experiments it is found, that on board an iron ship the vertical force below the compass is about nine-fourteenths of that which was observed on shore, we may expect in these latitudes very little change of deviation from heeling. To determine this we must have recourse to vertical vibrations. We have observed above that on shore the needle vibrated vertically, when at right angles to the horizontal line of force, 33 times in the minute. Now if this vertical needle on board an iron ship vibrates 26½ times in the minute, we should expect that the deviation in this magnetic latitude would not be much affected by heeling, because, adopting the above empirical rule, the square of 26½ = 702, is to the square of 33 = 1089, nearly as 9 is to 14.

It must, however, be observed, that this empirical rule only refers to compasses, the quadrantal deviations of which are allowed to

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* Having determined the value of the resultant force of the earth's and ship's magnetism, with the head of the latter both east and west by compass, the force of the induced magnetism of the athwart-ship iron will be unity, minus half the sum of these forces. In the case of the "Simla's," it would be,—

$$1 - \frac{1{\cdot}034 + {\cdot}2639}{2} = {\cdot}35105$$

When the "Simla's" head was east, the earth's horizontal force, plus the ship's sub-permanent force, minus the ship's transverse inductive force being 1·034, the ship's sub-permanent force towards the port side (— C) was equal to ·385, because,

$$1 + {\cdot}385 - {\cdot}351 = 1{\cdot}034$$

But when the ship's head was west, the sub-permanent and induced magnetism of the ship were both minus. Employing the same quantities the result will also agree with those determined by our vibration experiments :—

$$1 - {\cdot}385 - 351 = {\cdot}264$$

To determine the total value of + D produced by the induced magnetism of transverse iron, we have—

$${\cdot}351 \times \text{sin. } 45° \times \text{cos. } 45° = {\cdot}1755 = \text{sin. } 10°\ 6′ = \text{sin. D.}$$

(See foot note to section 68.)

remain uncompensated. For instance, in the case of the compass on board the "Simla," above alluded to, it appears that more than four-fifths of the change of deviation from heeling arises from the same source as the D = + 10° (68). If, therefore, three-quarters of this source of error (10° − 2° 10′ = 7° 50′) be compensated by correctors or chain boxes, the deviation would only be one-third as much affected by heeling as it would have been if the quadrantal deviation had remained uncompensated.*

Having considered the expediency of attempting further to compensate the + D by − D, and thus still more to reduce the varying source of error, arising from heeling, we have come to the conclusion that we should not, with present data, succeed in our endeavours to effect a permanent compensation of this source of errors of a compass on board a ship engaged on voyages from one hemisphere to the other. We have shown (12) that the horizontal sub-permanent magnetism acquired whilst the ship was being built has been considerably reduced in a few days, during which the ship's head has been principally in a different position. How much more, therefore, may we suspect that the vertical sub-permanent magnetism may undergo a change from the earth's vertical magnetic influence being reversed for months together, which it often must be when in the southern hemisphere. Also the vertical retentive magnetism must always be of a contrary name in the southern, to that which it acquires in the northern hemisphere. Although we have only the observations of Capt. Williams of the "Simla" to confirm this hypothesis, it is recommended, at present, that when a compass on board of an iron ship which sails from one hemisphere to the other, is compensated for heeling, it should only be regarded as a temporary expedient not to be depended on in other magnetic latitudes, nor even on returning to port after a voyage to the other hemisphere, unless

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* Referring back to foot note to section 68, m is equal to $\frac{h}{\cos. c d}$, h being the magnetic force, by induction, when the iron is in the direction $o c$. Having, on board the "Simla," ascertained $h = \cdot 351$, and the dip $c d = 70°$,

$$\frac{351}{\cos. 70°} = 1 \cdot 01126 = m$$

And the coefficient C produced by heeling caused by a change in the inductive magnetism of transverse iron—

$$\sin C = m \cdot \cos. dn \cdot \cos. hn$$

$$\therefore \sin. C\ 9° 30' = \cdot 165 = 1 \cdot 01126 \ . \cos. 20° \ . \cos. 70.$$

The total change of the deviation of the compass of the "Simla," produced by 10° heel either to port or starboard, was 11° 30′, and consequently ·826 of the change of the deviation from heeling arose from the induced magnetism of athwart-ship iron. But the whole of the + D has never been compensated by correctors (see above); because some portion (2° 10′ in the case of the "Simla") was already compensated by fore and aft horizontal iron. But the D + 7° 50′, observed whilst the ship was on an even beam, should be compensated by correctors or chain boxes. By the formulæ, contained in foot note 68,—

$$m = \frac{2 \ . \sin. 7° 50'}{\cos. 70°} = \cdot 797$$

$$\therefore \ .797 \ . \cos. 20° \ . \cos. 10° = \cdot 1301 = \sin. 7° 29',$$

and 7° 29′ is that part of the change of deviation, compensated by the correctors. The total change in the value of C was 11° 30′, but this would be reduced to 4° if the *D observed* while she was on an even beam were compensated.

re-adjusted from time to time with every altered circumstance. Not so, however, with the compasses of ships engaged in the trade between Great Britain and North America, or any other places in or near the same magnetic latitude. With them the pole below the compass is not likely to change its force, because the earth's vertical magnetic force continues to affect the ship in the same line as it did when the ship was being built. Nor is it in such cases of much importance to determine how much of the effects of heeling arises from the sub-permanent pole of the ship's magnetism below the compass and how much is the effect of the induced magnetism of athwart-ship iron, since both may be compensated by a vertical magnet below the compass whilst the ship is in the same magnetic latitude. The manner in which this is accomplished will be described in Appendix D.

Appendix C.

The Details to be observed in compensating the Standard Compass of the "City of Baltimore," the table of deviations of which compass uncompensated is given in Section 58.

The ship's head should be brought to the east correct magnetic, and the — B should be approximately compensated by placing the fore and aft magnets with the poles that attract the north end of the needle, towards the bows and sufficiently near to the compass to make it show the ship's head east. The ship's head should then be swung north correct magnetic, and, for the purpose of compensating — C, the pole of the athwart-ship magnet, that attracts the north end of the needle, should be placed towards the starboard side, at the distance required to make the ship's head appear north by compass (in both these cases all the requirements named in section 46 must be strictly observed). The "City of Baltimore" having being built with her head near the north, correct magnetic, only one athwart-ship magnet is required, although, for the same reason, two fore and aft magnets will probably be necessary, one on either side of the compass. Whilst the ship's head is still north the direction of the brackets for supporting the cast-iron correctors should be tested, to ascertain whether the line of the centres of the correctors and that of the compass is exactly at right angles to the fore and aft midship line of the ship. For this purpose the starboard corrector should be first placed in position, and if the ship's head continues to be north by compass the bracket is shown to be correctly placed, but should it make the ship's head appear west of the north the bracket is too far forward, and *vice versâ*. Should the starboard corrector be in error, the port corrector should next be tested in the same manner, only in this case the ship's head will appear east of the north if the corrector is too far forward, and *vice versâ*. If it be found that only one corrector is in error, the compensation should be proceeded with, and the corrector in error may be

afterward adjusted, so as at the same time to compensate the B that arises from the magnetic condition of the ship. But should both be in error, one should be corrected by moving the bracket towards the bows or stern so as to make the ship's head north by compass, when that bracket should be *finally* fixed.

The ship's head should be then swung to the south by compass, when the deviation would be found to be 5° W.; then bring the ship's head to the west by compass, when the deviation would be 1° 0′ W. In section 53 we find that coefficient A is equal to one-quarter of the algebraic sum (52) of the deviations observed with the ship's head on the four cardinal points; but in this case, there being no deviation with the ship's head north or east, A will be equal to one-quarter of the algebraic sum of the deviations observed with the ship's head south and west, that is, A is equal to −1° 30′. For the same reason E is equal to one-quarter the sum of these deviations, reversing the sign of the deviation observed with the ship's head west (57), making E equal to −1°.

Having thus determined the values of A and E, we are able to perfect the compensation of A, B, and C. For this purpose the ship's head should again be swung correct magnetic north, and for the purpose of compensating A − 1° 30′, the needle must be moved to the left on the compass card sufficiently to make the ship's head to appear by compass N. 1° 30′ W. (29). If E be compensated it must be done after the correctors are placed in their position to compensate D, therefore to perfect the compensation of C the athwart-ship magnet should be removed so much further from the compass as to make the ship's head appear N. 1° E., thus showing a westerly deviation of 1° produced by coefficient E. −1° (29). For the purpose of compensating B the ship's head must be brought east correct magnetic, since with the ship's head east, − E gives easterly deviation; the fore and aft magnets should be removed further from the compass until the ship's head is made to appear E. 1° N. by compass. The ship's head may now be swung S.E., and the correctors should be slidden sufficiently near to make the ship's head appear S.E. by compass. If it is thought desirable to compensate the remaining coefficient E, the ship's head must be again brought north correct magnetic, where by compass the ship's head will appear N. 1° E. the result of E − 1° (29). This E will be the united effect of the corrector that was suffered to remain in error and of the magnetic condition of the ship. To compensate which, if the corrector in error be the starboard one, the bracket must be moved towards the bows, but if it be the port corrector towards the stern until the ship's head appears north by compass.

The ship should be then swung for remaining deviations, which in the case above will be found to be too small to require tabulation, because in each quadrant, the value of D is nearly the same. But this is not always the case, and consequently remaining deviations cannot always be avoided. In the case of the bridge *compass* of the "Ionia" the value of D in the N.W. quadrant

is nearly three degrees greater than it is in the N.E. quadrant. In such cases it is desirable that the quadrantal deviation should be compensated in the quadrant in which it is greatest, and the remaining deviations tabulated in the other three quadrants;—because the change of deviation, from heeling produced by the altered position of athwart-ship iron, will be less when + D is over-compensated than it would have been if under-compensated (68); and by the same means a greater amount of directive force will be restored to the compass needle; it is also desirable because when a ship at sea is kept for a considerable time with her head in one direction, the value of + D is generally greater than was observed when swinging the ship.

The following Details should be observed when a Compass has similar Deviations to those of the Bridge Compass of the "Ionia," alluded to above, in which the value of D is different in each of the four quadrants.

The magnets having been approximately placed in position whilst the ship's head was east and north, correct magnetic, in the manner described in the last example, the ship's head should be swung south by compass, when her head would be found to be S. 2° 30′ W., correct magnetic, showing a deviation of 2° 30′ E. The ship's head should be then brought west by compass, when it would be found to be S. 85° W., correct magnetic, showing a deviation on this point of 5° W. One-quarter of the sum of these deviations, about — 0° 38′, would be the value of A, and reversing the sign of westerly deviation a quarter of the sum would be — 1° 52′, the value of E.

After the completion of this process the deviation on the eight principal points would be those given in Part I. of the following Table.

Direction of Ship's Head by Compass.	I. Deviations approximately compensated by Magnets when Ship's Head was North and East.		II. Coefficients A, B, C, and E, compensated, also D, whilst Ship's Head was N.E.		III. + D compensated in the quadrant in which it had been greatest.	
	Direction of Ship's Head, correct Magnetic.	Remaining Deviations.	Direction of Ship's Head, correct Magnetic.	Remaining Deviations.	Direction of Ship's Head, correct Magnetic.	Remaining Deviations.
		° ′		° ′		° ′
North	North.	0 0	North.	0 0	North.	0 0
N. 45° E.	N. 47° 25′ E.	2 25 E.	N. 45° E.	0 0	N. 42° 10′ E.	2 50 W.
East.	East.	0 0	East.	0 0	East.	0 0
S. 45° E.	S. 46° 43′ E.	1 43 W.	S. 46° 34′ E.	1 34 W.	S. 43° 44′ E.	1 16 E.
South.	S. 2° 30′ W.	2 30 E.	South.	0 0	South.	0 0
S. 45° W.	S. 47° 35′ W.	2 35 E.	S. 46° 56′ W.	1 56 E.	S. 44° 6′ W.	0 54 W.
West.	S. 85° W.	5 0 W.	West.	0 0	West.	0 0
N. 45° W.	N. 53° 17′ W.	8 17 W.	N. 47° 50′ W.	2 50 W.	N. 45 W.	0 0

The ship's head having been brought N.E., and the deviation then observed having been compensated in the manner described in the last example, it should be again swung to the north, and — E compensated as before described. The ship's head should be now swung to the eight principal points of the compass, when the remaining deviations would be found to be those given in Part II. of the above Table. Whilst the ship's head was still on the N.W. point, that corrector, which has not been disturbed in compensating E, should be slidden so much nearer to the needle as to make the ship's head appear N.W. by compass. The deviations will now be those given in Part III. of the above table.

One of the advantages derived from the complete compensation of the deviation for the four cardinal points is the facility with which the deviations for each of the other points can be determined, where, from the nature of the magnetic condition of the ship, remaining deviations are necessary. Having determined that the deviations on three of the four point courses are those given in Part III. of the above table, we should reduce them to minutes, that is, at N.E. 2° 50′ W = 170′ W., at S.E. 1° 16′ E. = 76′ E., and at S.W. 54′ W. We then open Table I. of Norie's for two points, with the above numbers in the distance column, and take from the lat. column 157′ = 2° 37′*, 70′ = 1° 10′*, and 49′ 9*, say 50′. Then with the same numbers in the distance column of the four points page we have 120′ = 2°, 53′·7, say 54′, and 38′. Also from the page for six points, at the bottom, 65′ = 1° 5′*, 29′*, and 20′·7*, say 21′. Then in a table constructed like the one below, enter against the respective points given in Part III. of the above table, the deviations there given, and against the points adjoining these both above and below, enter the quantities taken out from Table I. of Norie's for two, four, and six points successively in each quadrant, retaining the same sign as that given in Part III. of the above table.

Direction of Ship's Head by Compass.	Remaining Deviations.	Direction of Ship's Head by Compass.	Remaining Deviations.	Direction of Ship's Head by Compass.	Remaining Deviations.	Direction of Ship's Head by Compass.	Remaining Deviations.
	° ′		° ′		° ′		° ′
North.	0 0	East.	0 0	South.	0 0	West.	0 0
N. by E.	1 5 W.	E. by S.	0 29 E.	S. by W.	0 21 W.	W. by N.	0 0
N.N.E.	2 0 W.	E.S.E.	0 54 E.	S.S.W.	0 38 W.	W.N.W.	0 0
N.E. by N.	2 37 W.	S.E. by E.	1 10 E.	S.W. by S.	0 50 W.	N.W. by W.	0 0
N.E.	2 50 W.	S.E.	1 16 E.	S.W.	0 54 W.	N.W.	0 0
N.E. by E.	2 37 W.	S.E. by S.	1 10 E.	S.W. by W.	0 50 W.	N.W. by N.	0 0
E.N.E.	2 0 W.	S.S.E.	0 54 E.	W.S.W.	0 38 W.	N.N.W.	0 0
E. by N.	1 5 W.	S. by E.	0 29 E.	W. by S.	0 21 W.	N. by W.	0 0

* Since the departure for two points is the difference of latitude for six points, these may both be taken out at the same time.

Appendix D.

Compensation for heeling.

In section 72 compensation for the change of deviation from heeling is alluded to. When this is adopted the binnacle should be provided with a rectangular pillar, made of well-seasoned wood, two inches and three-quarters wide and two inches and a quarter deep. In the front of this pillar there should be a square groove cut, an inch and three-quarters deep and the same breadth. Into this groove should be fitted a wooden case, the outside dimensions of which should be one inch and three-quarters square and nine inches long, and should be so fitted into the groove as to slide without shake up and down the groove, and round the pillar should be fitted two stout bands of brass, each having two strong clamp screws, one in front and the other behind, for the purpose of firmly fixing the magnet case at any distance from the compass. Through the whole of the centre of the case there should be a hole one inch and a sixteenth square, into which should be introduced a magnet an inch square and nine inches long, which should be jammed into the centre of the case by means of eight wide and very acute wedges, one on each side of the magnet and at both ends. There should be a door in front of the binnacle to allow access to the vertical magnet case for the purpose of adjusting it. There should be two spirit levels attached to the binnacle, one to the front and the other to either of the sides, and when the binnacle has been placed perfectly upright both spirit levels should be adjusted to bring the bubbles in the centres, with the lubber line exactly north by compass. The magnet should then be clamped in the groove of the pillar near the top, with the end that repels the north end of the needle upwards. If the lubber line then appears east of north the centre of the magnet is to the east of the centre of the compass, and the top of the pillar should therefore be moved towards the west sufficiently to bring the north point of the compass to the lubber line. The magnet should then be removed, and the lubber line brought to the east by compass, and by tilting the binnacle, the bubbles of both spirit levels should be brought to the centre. The magnet should be then replaced in the groove, and if the lubber line appears to the north of east the top of the pillar should be moved towards the south, and *vice versâ*. The upper end of the pillar should now be fixed and the magnet slidden down as near as convenient to the bottom of the groove, and with the ship's head at first east and afterwards north the position of the bottom of the pillar should be adjusted. The same rules will now apply in determining the right position for the bottom of the pillar as those given above for the adjustment of the top of the pillar. The last adjustment is for the purpose of placing the line of the poles of the magnet so as to correspond exactly with the line that passes through the centre of the magnet case. For this purpose the ends of the magnet case must be reversed in the groove, that is, the pole of the

magnet that attracts the north end of the needle should be placed upwards. Then make the lubber line north by compass with the magnet out. If it should appear west of north with the magnet in, the upper pole of the magnet is too far east (29). This should be corrected by slackening the wedge on the west side of the magnet and driving forward the wedge on the east side. In the same manner with the lubber line east by compass with magnet out, if with magnet in, it should appear north of east, the northern wedge should be slackened and the southern driven on until the lubber line appears east by compass. In each of these experiments care should be taken to see that the bubble of each spirit level is in the centre of the tube. This adjustment being completed, the magnet should be permanently fixed in the case by pouring into the interstices between the magnet and the case a solution of shell-lac in naphtha.

Directions for fixing the Binnacle and compensating for Heeling on ship-board.

The arrangements above described having been made on shore for the compensation for heeling, the binnacle should be fixed in its place on board whilst the ship is exactly on an even beam, and at the same time the clinometer (79) should be fixed in its place, with the index at zero. In fixing the binnacle it should be so tilted as to bring the bubbles of both spirit levels to the centre of their tubes. The compass having been compensated whilst the ship was on an even beam, as described in Appendix C., when practicable the ship should be heeled to starboard about 10°, with her head in the direction which was north by compass when she was on an even beam. If the needle be drawn to the west, which will be indicated by the ship's head appearing to be east of north by compass (29), the magnet should be placed in the groove with that pole which repels the north end of compass upwards, and should then be clamped sufficiently near the needle to make the ship's head appear north by compass. But in the exceptional cases in which the north end of the needle is drawn to the lower side of the ship, which with a starboard heel before the magnet was in place would make the ship's head appear west of north, the pole that attracts the north end of the compass should be uppermost (29). Since, however, it sometimes occurs that the compass is affected more by heeling to starboard than to port, and at other times the reverse, the ship should be also heeled to port and the deviation from heeling in this direction also noted. In the case of the standard compass of the "City of Baltimore" (74), if the vertical magnet were placed so as to cause no change of deviation when the ship was heeling to starboard, if heeled 10° to port, it would, with her head north by compass, be found to have been over-compensated 2° 30′, which would be indicated by the needle having been drawn 2° 30′ towards the lower side of the ship, making the ship's head appear *by* compass N. 2° 30′ E. (29). It is desirable that this error should

be divided between the starboard and port heel, therefore the vertical magnet should be lowered until the ship's head appears N. 1° 15′ E. Under which circumstance the compass would have a change of deviation amounting to 1° 15′ W. either by heeling 10° starboard or 10° port.

When it is not practicable to heel an iron ship in port, still it may be advisable to make arrangements in the binnacle for receiving a vertical magnet as above described, and fixing the binnacle with the bubbles of each spirit level in the centre of the tube. Then in going down channel, if sailing on a wind with ship's head as nearly south by compass as is convenient, the true magnetic bearing of some distant object should be determined, or the azimuth of some heavenly body calculated (106 to 118), and, at the same time, its bearing by compass observed, by means of which the deviation should be determined. The difference between this deviation and the remaining deviation of the same compass, whilst the ship was on an even beam will be the change of deviation caused by heeling. In most cases the magnetism of the ship below the compass attracts the north end of the needle, producing an easterly* or westerly change of deviation, according as the wind is easterly or westerly by compass. To compensate this change of deviation from heeling, the vertical magnet must be placed in the groove with the pole that repels the north end of the needle upwards, and should be then raised sufficiently near the compass to reduce the deviation to the remaining deviation, with the ship's head in the same direction by compass when on an even beam, (*see* Appendix C.) But if the change of deviation from heeling be westerly with the wind easterly, or easterly with the wind westerly (which would be the case with the standard compass of the "Bloodhound" and the steering compass of the "Recruit," 70) the magnetism below the compass repels the north end of the needle, to compensate which the pole of the vertical magnet that attracts the north end of the needle should be placed upwards.

The vertical magnet having been placed in the position to restore the remaining deviation observed after the compass had been compensated on an even beam (*see* Appendix C.), the vertical magnet should be securely clamped; but to guard against the insufficiency of the clamps to retain the vertical magnet in its proper position, it is desirable that a piece of wood, the length exactly corresponding with the distance between the bottom of the groove and the lower end of the magnet, should be placed in the groove below the magnet and fastened there by means of a lashing round the pillar near each end of the stick.

Example, 1865, May 7, 7^h 12^m p.m. at ship. The "Ionia" going down channel, in lat. 53° N., long. 5° W., ship's head

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* The change of deviation is easterly either when east deviation is increased, west decreased, or west deviation changed to east; and the change is westerly either when west deviation is increased by heeling, east decreased, or east deviation is changed to west.

bearing S. by W., wind W. by N., ship heeling 9° to port by clinometer; the bearing of the sun by compass N. 30° 40′ W.

Approx. dec. N. 17°
App. time at ship 7h 12m p.m.

Arc I. 44° 41′ log. I. 10·3400
Lat. N. 53 0

97 41
180

82 19 log. II. 0·0039

Sun's true azimuth N. 65° 40′ W. 10·3439

Sun's bearing by compass N. 30 40 W.

Correction 35 0 W.
Variation 25 0 W.

Deviation 10 0 W.
Remaining deviation ship's head S. by W. 0 21 W.

Change of deviation for heeling 9 39 W.

The change of deviation being west with the wind westerly indicates, in accordance with the above rule, that the pole of the vertical magnet that repels the north end of the needle should be upwards when the vertical magnet is fixed in the groove, and should be clamped sufficiently near to the compass to reduce the deviation to 0° 21′ W. with the ship's head S. by W.

1865, November 29, 8h 24m a.m. at ship. The "Ionia" returning to port, after a voyage to the southern hemisphere, in lat. 49° N., long. 7° W., the ship's head north by compass, the wind being east, she was heeling 7° to port by clinometer; the sun bore by compass S. 20° 30′ E.

Approx. dec. S. 21° 30′
App. time at ship 8h 24m

Arc I. 33° 50′ log. I. 10·0582
Lat. N. 49 0

82 50 log. II. 0·0034

Sun's true azimuth S. 49° 0′ E. 10·0616

Sun's bearing by compass S. 20 30 E.

Correction 28 30 W.
Variation 24 30 W.

Deviation 4 0 W.

In the previous example, explaining the compensation for heeling when first leaving port, the magnet was fixed in the groove with that pole which repels the north end of the needle upwards, to compensate a westerly change of deviation caused

by a heel produced by a west wind, according to the rule before given. The deviation being now westerly by a heel produced by a east wind, it is evident that the magnet is too near the compass for the present magnetic condition of the ship ; it should be therefore lowered until the correction and the variation agree, there being no remaining deviation for this compass with her head north correct magnetic on an even beam.

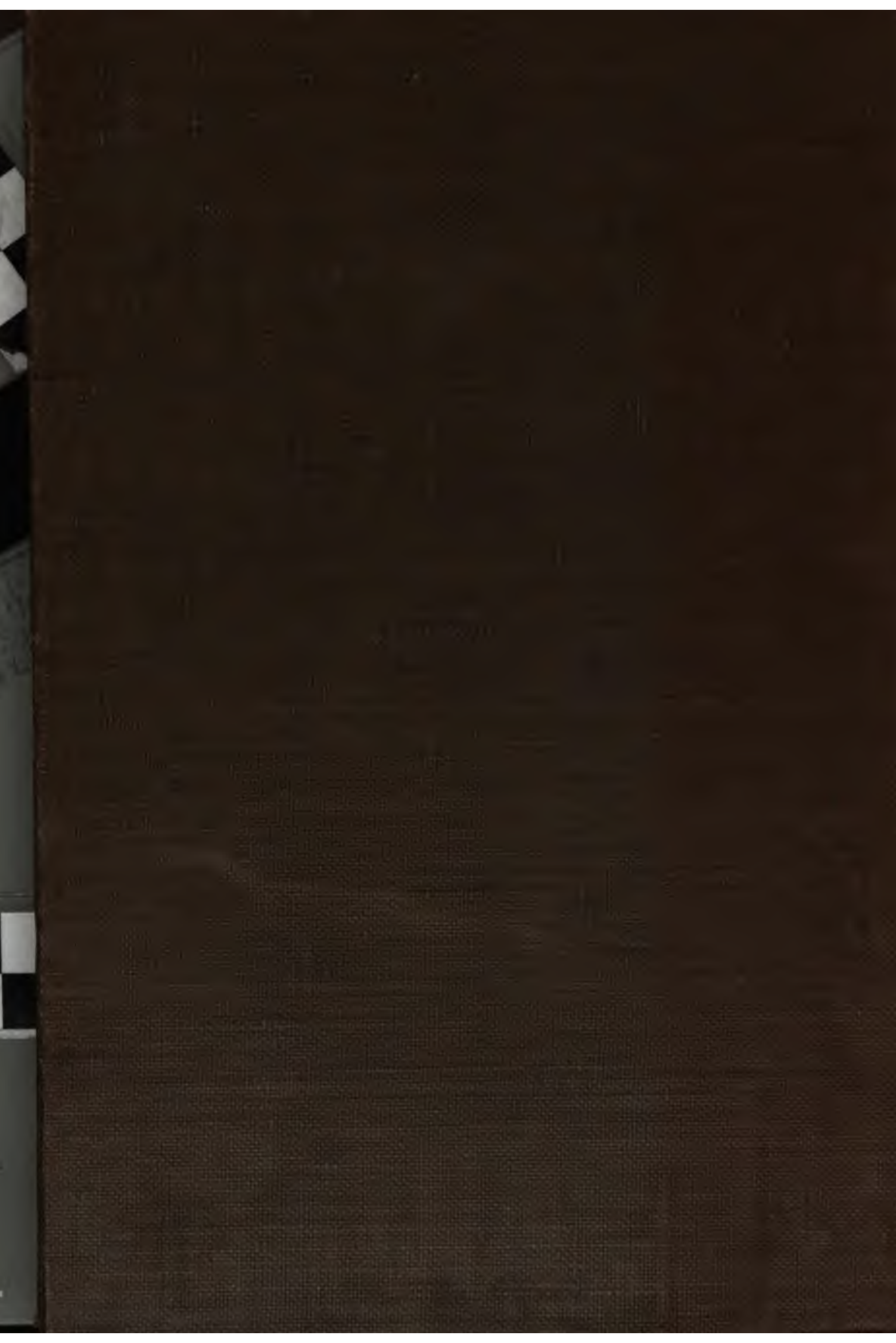
The following table shows the result of heeling experiments on board the iron sailing ship "Simla," made in August 1858. In this case the magnet was adjusted whilst the ship was on an even beam, in conformity with the empirical rule given in the foot note to section 70, and further alluded to in Appendix B.

Ship's Head by Compass (disturbed).	10° Heel to Port.		Ship Upright.	10° Heel to Starboard.	
	Without Vertical Magnet.	With Vertical Magnet.		With Vertical Magnet.	Without Vertical Magnet.
	° ′	° ′	° ′	° ′	° ′
North.	13 50 W.	25 20 W.	24 10 W.	27 40 W.	39 10 W.
N. by E.	7 20 W.	18 40 W.	18 45 W.	22 40 W.	34 0 W.
N.N.E.	2 55 W.	13 30 W.	12 10 W.	15 20 W.	26 0 W.
N.E. by N.	0 0	9 30 W.	6 15 W.	9 10 W.	18 50 W.
N.E.	1 40 E.	6 20 W.	2 0 W.	4 30 W.	12 45 W.
N.E. by E.	3 0 E.	3 20 W.	0 45 E.	3 30 W.	7 10 W.
E.N.E.	3 45 E.	0 30 W.	2 45 E.	1 30 E.	2 50 W.
E. by N.	4 15 E.	2 0 E.	4 10 E.	2 55 E.	0 40 E.
East.	4 0 E.	4 0 E.	5 15 E.	4 0 E.	4 0 E.
E. by S.	3 55 E.	6 10 E.	6 50 E.	5 10 E.	7 25 E.
E.S.E.	4 0 E.	8 25 E.	8 50 E.	6 40 E.	11 0 E.
S.E. by E.	4 30 E.	10 55 E.	11 10 E.	9 30 E.	15 45 E.
S.E.	5 45 E.	13 55 E.	14 15 E.	13 20 E.	21 15 E.
S.E. by S.	7 55 E.	17 30 E.	18 40 E.	17 20 E.	26 50 E.
S.S.E.	11 30 E.	22 10 E.	23 45 E.	22 10 E.	32 40 E.
S. by E.	14 30 E.	25 50 E.	27 45 E.	26 20 E.	37 30 E.
South.	16 50 E.	28 20 E.	29 50 E.	28 40 E.	40 0 E.
S. by W.	17 40 E.	29 0 E.	29 50 E.	28 35 E.	39 50 E.
S.S.W.	17 45 E.	28 25 E.	28 30 E.	27 20 E.	37 45 E.
S.W. by S.	16 30 E.	26 0 E.	25 45 E.	24 10 E.	33 25 E.
S.W.	13 55 E.	22 0 E.	21 45 E.	20 0 E.	27 20 E.
S.W. by W.	10 30 E.	16 50 E.	16 35 E.	14 10 E.	20 10 E.
W.S.W.	6 0 E.	10 25 E.	10 35 E.	10 0 E.	14 10 E.
W. by S.	1 10 E.	3 25 E.	3 50 E.	1 30 E.	3 45 E.
West.	3 30 W.	3 30 W.	3 0 W.	4 45 W.	4 45 W.
W. by N.	8 15 W.	10 30 W.	9 35 W.	11 0 W.	13 20 W.
W.N.W.	13 10 W.	17 30 W.	15 55 W.	17 10 W.	21 40 W.
N.W. by W.	17 10 W.	23 30 W.	21 20 W.	22 40 W.	29 10 W.
N.W.	20 40 W.	28 45 W.	25 35 W.	27 20 W.	35 35 W.
N.W. by N.	22 25 W.	32 0 W.	28 5 W.	30 20 W.	40 0 W.
N.N.W.	21 45 W.	32 20 W.	28 35 W.	31 40 W.	42 45 W.
N. by W.	19 15 W.	30 30 W.	27 30 W.	30 10 W.	42 35 W.

Appendix E.

The absurdity of attempting to insulate the Compass from the Magnetism of the Ship.

In connexion with compass deviations many practical men have vainly attempted to discover some substance or medium that would insulate the needle from the influence of the magnetism of the ship's iron. Many imagined discoveries of this character have been patented, and have served both to waste the time and money of the patentees, and to distract the attention of the mariner from that class of study which alone can promote his safety in navigating an iron ship. It may be stated with confidence that there is no available medium that can intercept magnetic influence. For two centuries, at least, every class of bodies has been submitted to experiment, in order to discover a material capable of intercepting the influence of one magnet on another, not for the purpose of preventing deviation, but because the mechanic clearly perceives that if such a material were discovered a motive power could be produced by various arrangements of permanent magnets and insulating bodies. But no one has succeeded in making this discovery. Should, however, the efforts, which for two centuries have been unsuccessful, be realized, although a new motive power would thereby be available, it would be altogether valueless in connexion with the compasses of iron ships. The magnetism of the earth generally, the loadstone, soft iron, hard steel, or the electro-magnet, is all of the same nature. If we shut off one we shut off all.

If, therefore, we could succeed in insulating the needle from the magnetism of the ship, we should by the same means intercept the magnetism of the earth, and thus the compass would be rendered absolutely useless. In the first place, then, the object sought for is not available; and, secondly, if such a medium did exist, it would be entirely valueless in connexion with the compasses of iron ships.

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